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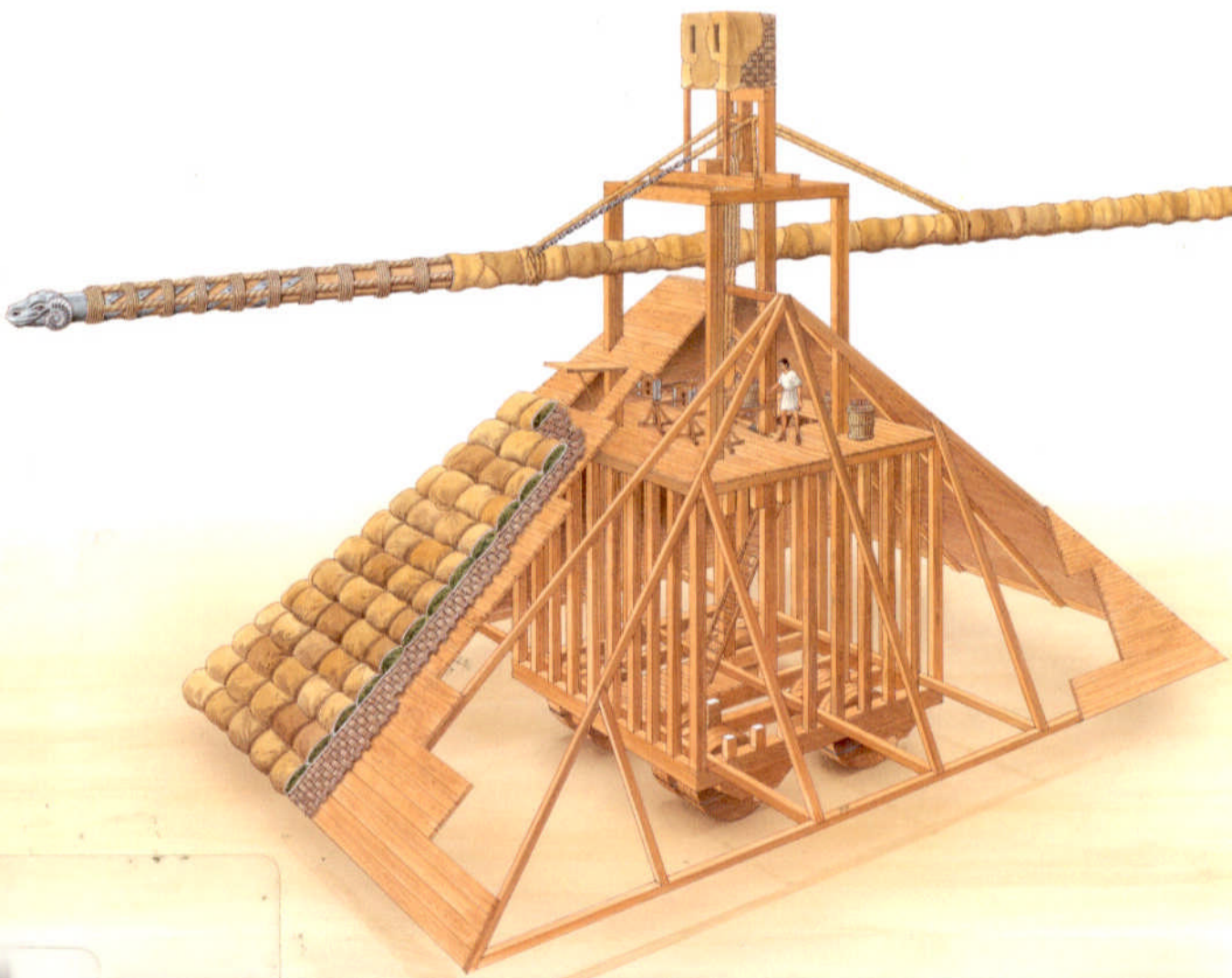
Greek and Roman Siege Machinery 399 BC–AD 363



Duncan B Campbell • Illustrated by Brian Delf

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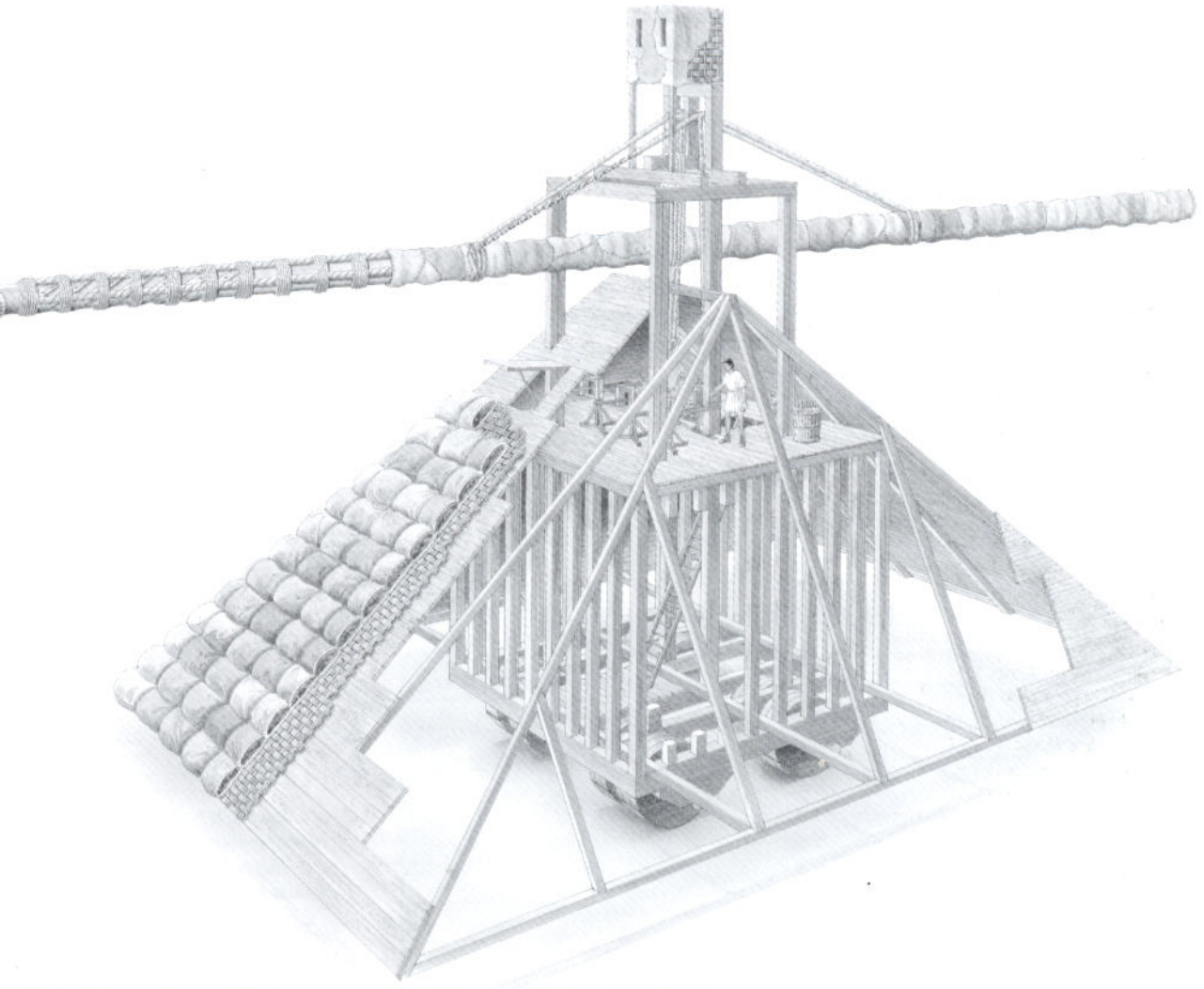

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Dedication

Itaque ego maximas infinitasque parentibus ago atque habeo gratias.
(Vitruvius, *De architectura* 6. praef. 4)

Artist's note

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A note on measurements

Although the Romans imposed a standard system of weights and measures across the empire, several different systems had existed in the Greek world. For example, the Greek foot, subdivided into 16 'daktyls', has been found to vary between 27 and 35cm, depending upon the geographical region. However, an intermediate value of 30.83cm was widely employed, and may be deemed an acceptable average. The standard foot of the Romans, by contrast, measured 29.57cm; it was similarly subdivided into 16ths (called 'digits', the Latin form of the Greek 'daktyls'), or into 12ths.
For readers of ancient engineering texts, the difficulty lies in deciding which system a particular author has employed. A Greek like Athenaeus, writing under the Roman regime, will naturally use the word 'daktyl'; but does he mean the Roman digit, or is he really using Greek daktyls? Any resulting inaccuracies will be minimal.

Greek measurements:
24 daktyls = 2 spans = 1 cubit = 46.24cm
16 daktyls = 1 foot = 30.83cm

Roman measurements:
24 digits = 2 spans = 1 cubit = 44.35cm
16 digits = 12 inches = 1 foot = 29.57cm

GREEK AND ROMAN SIEGE MACHINERY 399 BC–AD 363

INTRODUCTION

The fortifications around Mediterranean cities and towns in the 5th and early-4th centuries BC largely took the form of a 'great circuit'. The entire urban area was enclosed by a wall, taking maximum advantage of the terrain by following high ground or coastlines; towers reinforced potentially weak points, such as angles and gateways. Such a perimeter often ran to extreme length, but this posed no drawback, as it was not intended to be continuously manned. If sentries identified enemy forces massing for an attack, the relatively short lines of communication within the circuit meant that defensive efforts could quickly be concentrated at the threatened sector. In addition, by utilising natural defences as far as possible, the 'great circuit' denied the attacker the use of overwhelming numbers and forced him to negotiate difficult terrain. Properly defended, such a fortification was impregnable, in the absence of siege technology.

In the ancient Middle East, the Assyrians had been adept in the use of siege machinery, and there is some evidence that their Persian descendants made use of the battering ram. Of course, it is very likely that enterprising Western warriors would soon have discovered the value of a stout tree trunk in bursting open a gate. The historian Diodorus Siculus, writing in the 1st century BC, believed that Pericles had been the first Greek to use a battering ram, during the siege of Samos in 440 BC. His engineer, a certain Artemon, hailed from Clazomenae in present-day

The western fortifications of Messene. The rambling 'great circuit', dating to 369 BC, encloses the heights of Mount Ithome (to left), and follows ridges of high ground to discourage attackers. (A. W. Lawrence, courtesy of the Conway Library, Courtauld Institute of Art)

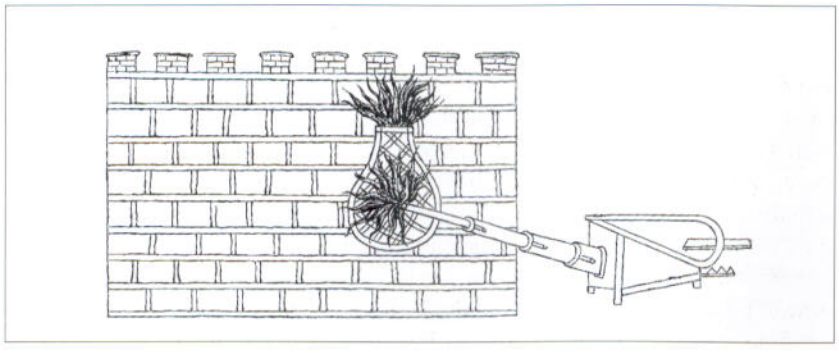
Turkey, where he may have had experience of Persian machines.

Nevertheless, besides the Spartan use of battering rams at Plataea in 429 BC, which were effectively countered by the defenders, the Greeks of the later-5th century showed no interest in siege -machinery. The machines (*mēchanai*) that the contemporary historian Thucydides mentions at several sieges of the period appear mostly to have been assault-ladders; the only glimpse of anything more complex is provided by the ingenious flame-throwing device that the Peloponnesian forces twice successfully employed against wooden fortifications.

At any rate, sophisticated siege machinery first appeared in the classical world in the hands of the Carthaginians, a people who traced their ancestry back to the Middle East. In the closing years of the 5th century BC, they deployed wheeled siege towers and battering rams against a string of Greek towns on Sicily. The experience prompted the ruler of neighbouring Syracuse, Dionysius I, to invest in his own siege-train, so he assembled a skilled workforce from all over the Mediterranean world and, by the year 399 BC, he possessed siege towers and battering rams, along with another weapon destined to play an important role in siege warfare: the catapult.

Large and complex machines would have been costly to construct and maintain, and almost by definition were only required by expansionist powers. So it is not surprising that they virtually disappeared for 50 years, before re-emerging in the Macedonian armies of Philip II and his son, Alexander the Great. On campaign, Philip was accompanied by engineers, one of whom, Polyidus of Thessaly, allegedly developed different types of battering ram. The same engineer was also remembered as the builder of a giant siege tower (*helepolis*) at Byzantium during Philip's siege of 340 BC. Alexander routinely utilised siege machinery, and several of his engineers are also known by name, emphasising the esteem in which they were held. Indeed, a pupil of Polyidus, named Diades, was known as 'the man who took Tyre with Alexander' in 332 BC.

Bronze head of a battering ram, found at Olympia, where it was probably dedicated amongst the spoils of war; the decoration suggests a late-5th-century date. It would have fitted a ramming-beam approximately 22cm high and 8cm thick. The vertical blade, flanked on either side by five triangular teeth, was perhaps designed to cut into mud-brick. (Courtesy of Deutsches Archäologisches Institut, Athens; neg. no. Olympia 2800)



10th-century manuscript illustration depicting a rudimentary flame-thrower. Thucydides mentions a 'machine' that comprised an iron pipe linking bellows to a cauldron, and which was used to destroy the wooden fortifications of Delium in 424 BC. The machine's appearance at Torone in the following year threw the defenders into panic. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

The battering ram in its simplest form was a beam carried by many men, such as this example depicted on Trajan's Column in the hands of Dacians attacking a Roman fort. It seems to have been conventional to fashion the head in the shape of a ram. (Author's collection)

Fortunately, later writers have preserved details of some of the machines designed by these men. For example, Biton, writing at some time between 231 and 133 BC, describes a siege tower built for Alexander by a Macedonian engineer named Posidonius. Biton cannot have known the machine at first hand, and must have drawn upon an earlier source, probably a treatise by the engineer himself or one of his pupils. Then there is the case of Vitruvius, who composed his ten-volume work *On architecture* (*De architectura*) in Augustan Rome (*c.* 25 BC). His section on siege machinery is strikingly similar to Athenaeus's treatise *On machinery (Peri mēchanēmatōn)*, and the two men probably drew upon the same sources of information; certainly, both claim to have studied the writings of Agesistratus and Diades, amongst others.

In the 4th century BC, siege machines were often unnecessarily large, as engineers attempted to push their skills to the limit. Epimachus the Athenian's 'city-taker' (*helepolis*), constructed for Demetrius Poliorcetes in 304 BC, was a 90-cubit (40m) iron-clad siege tower, probably armed with artillery. Amongst the successors of Alexander the Great, Demetrius is perhaps best known for his elaborate siege machines. It is possible that Hegetor of Byzantium's battering ram, mounted on top of a massive wheeled shed, was one of these.

WHEELED TOWERS

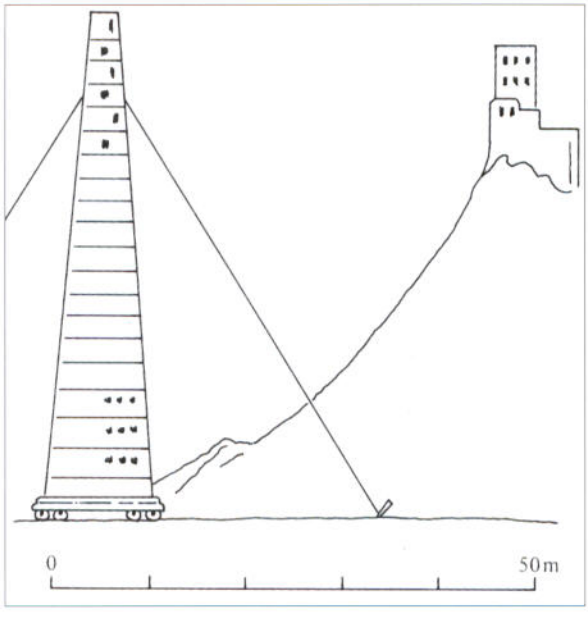
The Macedonian siege tower

The simplest way for troops to mount the enemy battlements was by ladder. However, such a manoeuvre was fraught with danger: the apparatus was often flimsy and easily repulsed, and the climbing troops were exposed to attack from above. The development of the siege tower made the process less hazardous, by providing a protected staircase with a gangplank or drawbridge, which could be let down onto the enemy wall. The machine's debut at Motya in 398 BC illustrates more or less this technique. In order to deny the Carthaginians a base there, Dionysius actually inserted his towers into the town through a breached wall, and used them to convey troops by gangplank onto the house-tops.

Of course, by its very nature, the siege tower also presented an elevated platform from which missile fire could be directed down onto the defenders on the wall-walk. At Perinthus in 341 BC, Philip II's siege

towers were 80 cubits (37m) high, allowing overwhelming firepower to be directed onto the towers and battlements, and probably the built-up area beyond. Alexander's siege towers at Tyre (332 BC) apparently towered over the walls, which were allegedly 150ft (c. 45m) high. The German scholar Erwin Schramm attempted to rationalise this astonishing claim by suggesting that the battlements ran along a cliff-top, which has since disappeared, but this seems unlikely.

Diades's instructions for building such a machine have been preserved for us in three ancient accounts: the works of Athenaeus and Vitruvius, both composed towards the end of the 1st century BC, and an anonymous Byzantine compilation, entitled *Siegecraft instructions* (*Parangelmata poliorkētika*). According to these, Diades prescribed two sizes of tower. The smaller version was 60 cubits (26.6m) high, and tapered from a base of 17 cubits (7.5m) square to 13½ cubits (6.0m) square at the top; the main upright timbers were ½ cubit (22cm) thick, decreasing to 7 daktyls (13cm) towards the top. It was divided into ten storeys, not in the form of complete platforms, but rather landings to support a system of internal staircases.



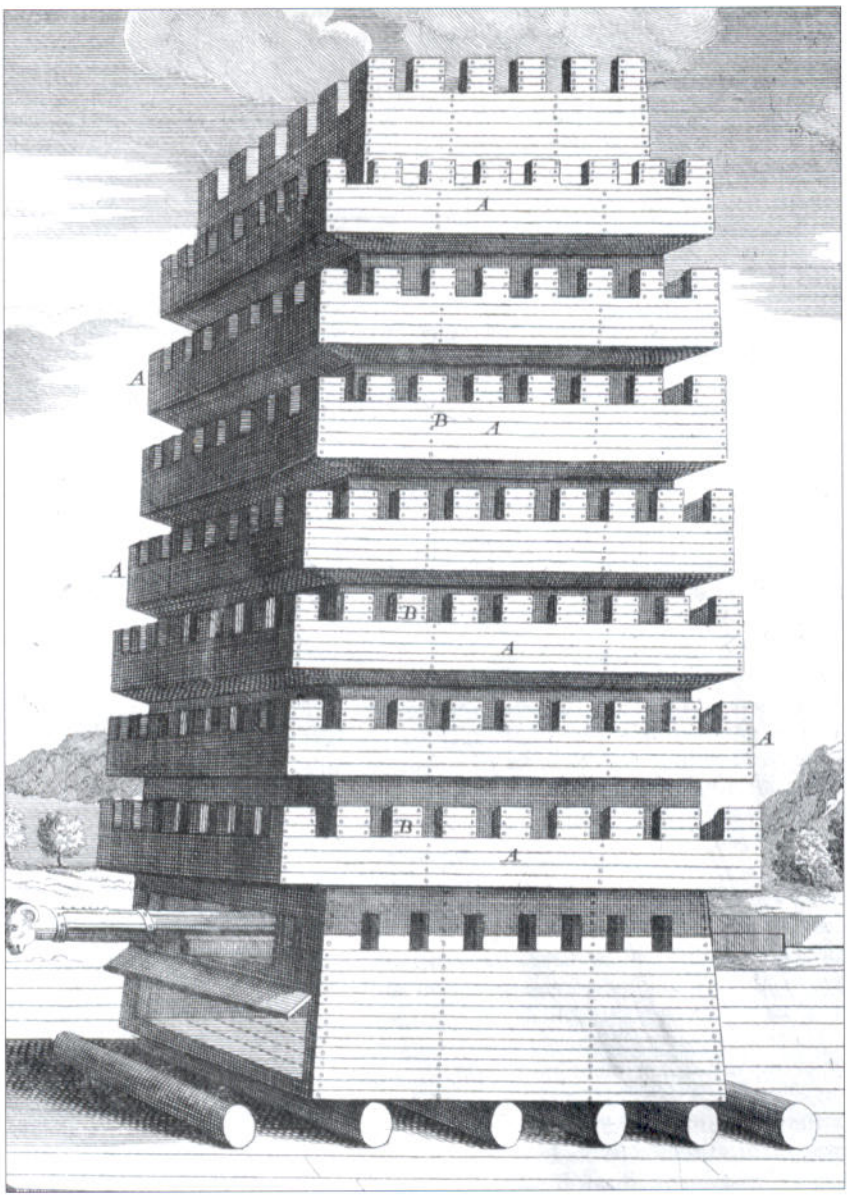
Schramm's theory of a cliff-top fortification at Tyre seems unlikely, as the present-day topography is flat. Nevertheless, his sketch illustrates how such gigantic siege towers might have been necessary against hill-top defences elsewhere. Although the terrain will not permit wheeled machinery to approach the foot of the wall, the upper storeys of the tower are well within missile range of the enemy battlements. (Author's drawing, after Schramm)

The larger version was an incredible 120 cubits (53.2m) high and 23½ cubits (10.4m) wide, tapering to around 19 cubits (8.4m) wide at the top; the foot-thick (30cm) main timbers decreased to 6 daktyls (11cm) higher up. Again, each of the 20 storeys took the form of a 3-cubit (1.3m) wide walkway around a central opening, through which the staircase rose in stages. The whole machine was covered with rawhide as a defence against fire.

Unfortunately, no details of the undercarriage have been preserved, although the anonymous Byzantine claims that the smaller tower sat on six wheels, and the larger on eight. Nor are there any instructions regarding the gangplank or boarding-bridge (*epibathra*) that must have been extended from the tower to carry the storm troops across to the enemy battlements. It was especially important to ensure that it could bear the weight of the combatants, unlike the first of Alexander's boarding-bridges at Massaga in 327 BC, which broke spilling the troops onto the ground and exposing them to missile fire from the battlements. Equally, the troops crossing the bridge required protection from flanking fire, and a waist-height wickerwork fence would have had the added benefit of preventing men from stumbling off the edge. Ironically, the sources note that Diades had promised to write on the subject of boarding-bridges, but never did.

The *helepolis* of Posidonius

The term 'city-taker' (*helepolis*) usually evokes the gigantic artillery-armed towers utilised by Demetrius Poliorcetes at the end of the 4th century BC, but the machine had a long pedigree. Polyidus was known as 'the man who built the *helepolis* at Byzantium', during Philip's unsuccessful siege of 340 BC. Although nothing is known about his



The 18th-century *Chevalier* de Folard made a detailed study of ancient military science. His reconstruction of the siege tower is ingenious, but inaccurate: it would have run on wheels, rather than this overly complex system of rollers, and the external galleries simply add to the machine's vulnerability. (Author's collection)

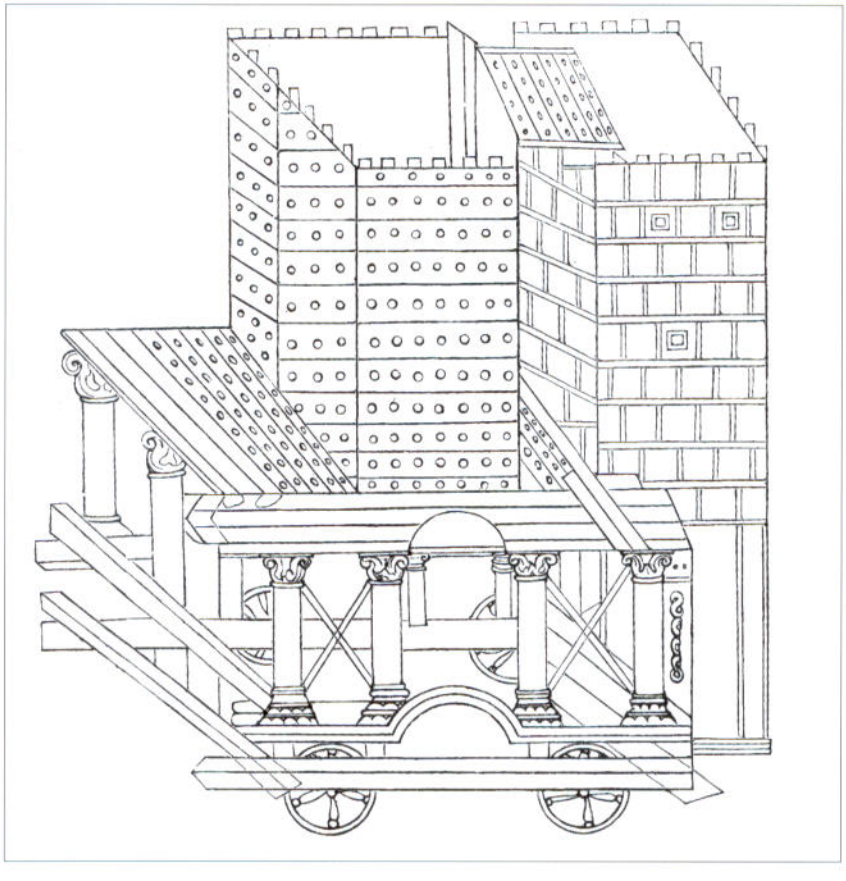
machine, it is likely that its purpose was to elevate missile troops to such a height that they commanded not only the battlements, but the interior of the town as well. The term *helepolis* perhaps came to be applied indiscriminately to any particularly impressive piece of siege machinery. Certainly, in the Roman era, it was briefly used to indicate a battering ram, but is still found associated with siege towers in the 4th century AD.

Posidonius's 'city-taker', described by Biton, was built for Alexander the Great, presumably in the 330s BC. In one of the few remarks on the optimum varieties of timber to use for siege machinery, he recommends fir or pine for the long timbers and the planking, but specifies hard wood like oak or ash for load-bearing components, such as the wheels and axles; and, in addition, the long beams should be reinforced with iron bands.

The brevity of Biton's description has led to confusion amongst modern scholars. In fact, not so long ago, it was customary to dismiss Biton as a worthless fraud. The Danish scholar Aage Drachmann went so far as to state that 'there is no sense in Biton at all', but that is too extreme a position to adopt; there is still much of value in his descriptions of siege machines.

The footprint of Posidonius's tower, at 60ft (18.5m) long by 50ft (15.5m) wide, was considerably larger than the contemporary siege towers of Diades. Biton says that the tower's axles were supported by an iron-strapped joist, 60ft (18.5m) long and 3ft (0.95m) high. The British scholar Eric Marsden suggested that both sides of the undercarriage comprised two such joists, side by side, sandwiching the wheels in between. Biton's text does not preserve this level of detail, but the suggestion is sensible as the same type of construction is found later, in Roman machines. There must also have been crossbeams.

The bottom storey apparently sat on 2ft-high (0.62m) posts, fixed to the joists above the axles. According to Biton, with the posts in position, the rims of the wheels 'rubbed' (presumably against the floor above) and the men pushing the machine (i.e. standing on the ground between the timbers of the undercarriage) were not cramped. If we assume that the joists sat on the axles, there will have been a 5ft (1.5m) gap between the axle and the timbers of the first floor. Biton's reference to 'rubbing' implies that the wheels took up much of this space, and must have been a shade less than 10ft (3m) in diameter, which would certainly have given the pushing-crew ample headroom.

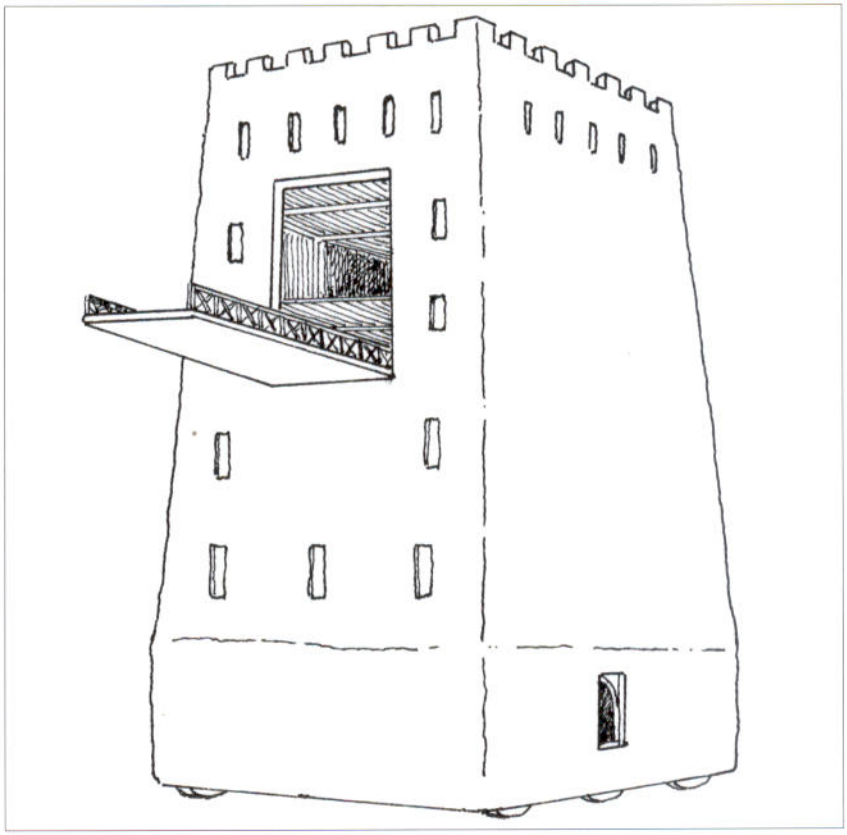


Posidonius's *helepolis*. It is unlikely that this manuscript illustration, dating to the 11th/12th century, is in any way faithful to Biton's original diagram. For one thing, Biton's text presupposes that the main elements of the machine were labelled on the drawing with Greek letters. This Byzantine drawing probably represents the attempt of an early reader to reconstruct the machine from the instructions alone. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

However, Biton later states that the wheels were only 3ft (0.92m) in diameter and 9ft (2.8m) in circumference. Marsden took a somewhat cavalier approach to the text, proposing 6-cubit-high (2.8m), 4ft-thick (1.2m), spoked wheels, and claiming that Biton's 3ft diameter applied only to the wheel-hubs. However, the division of the wheel into spokes would have introduced an unnecessary weakness, and it seems unlikely that such a massive machine would have been equipped with anything other than solid wheels. Furthermore, wheels of 3ft in diameter would have made moving the machine excessively difficult – the larger the wheels, the easier the movement. It seems more likely that Biton's figure of 3ft was the width of the wheels, and 9ft was the height.

Biton goes on to describe, in a convoluted fashion, an arrangement of beams and posts that apparently formed the 17ft-high (5.2m) chassis of the *helepolis*. Both long sides of the machine were provided with a central arched doorway (*propylis*), giving access to the interior of the chamber, where the staircase leading to the upper levels would have started.

The rest of the machine is a little vague. At the outset, Biton sensibly advises that siege towers should be tailored to the height of the enemy wall, but he later suggests a 50-cubit (23m) superstructure, presumably rising above the 17ft chassis and 9ft undercarriage, resulting more or less in a 100ft (31m) tower. It was not the tower height which was most crucial, but the positioning of the boarding-bridge within, so that when the machine was drawn up



Suggested reconstruction of Posidonius's *helepolis*. The design of the assault-bridge is conjectural. (Author's drawing, following Lendle's interpretation)

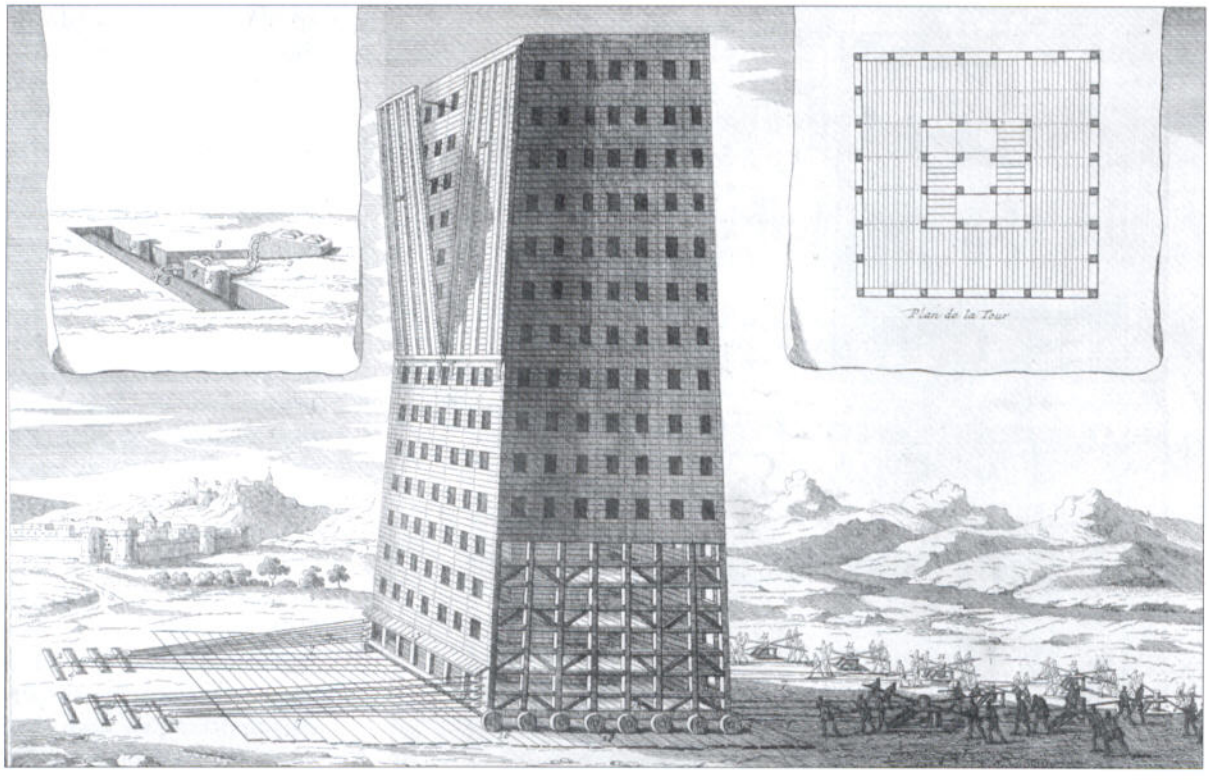
at the enemy wall, the troops could storm across onto the battlements. Unfortunately, Biton does not explain how this feature worked, but it clearly required an opening in the front face of the tower in order to provide an exit for the storm troops.

As for the boarding-bridge itself, there are two possibilities: first, the bridge could have taken the form of a gang-plank, stored horizontally within the tower and slid forward through an opening, perhaps on rollers; or, second, it could have been fitted vertically on the tower's exterior, hinged at the bottom like a drawbridge and lowered by a winch mechanism. The latter seems to be the more practical option, although the Romans apparently used both.

Biton states that the exterior was plastered with lime and covered with sheep's wool fleeces. This was just one of many schemes utilised for fireproofing siege machines. Writing in the later-3rd century BC, Philon of Byzantium recommends that exposed timbers should be daubed with a mixture of ash and birdlime (a sticky substance derived from mistletoe berries) as a protection against fire, and mentions the use of wool fleeces soaked in vinegar or water. No doubt, a fleece layer also helped to absorb the impact of missiles.

The *helepolis* of Epimachus

A generation later, Epimachus built a *helepolis* for Demetrius Poliorcetes's siege of Rhodes (304 BC). Details this time come from four ancient authors: Athenaeus and Vitruvius, again; the historian Diodorus Siculus; and Demetrius's biographer, Plutarch, writing around AD 100. Of course, all will have consulted earlier sources, perhaps even a lost work by Epimachus himself; Diodorus's account, in particular, has the flavour of having been drawn from a technical work. He records that the machine's undercarriage, or 'grid-iron' (*escharion*), had sides measuring 'almost 50 cubits' (23m), which squares with the 48 cubits (21m) recorded by Plutarch and Athenaeus; Vitruvius's '60ft' (17.75m) is obviously a mistake. Diodorus says that crossbeams partitioned the interior of the undercarriage at one-cubit (46cm) intervals, for the men to push against in moving the machine.



De Folard's reconstruction of the *helepolis* of Epimachus incorporates several errors, such as the number of wheels, the number of storeys, and the provision of gigantic drawbridges. But it demonstrates the inventive use of the block-and-tackle for winching the machine forwards. (Author's collection)

The machine rolled on eight wheels, but it is unknown whether they were arranged in two rows, each with four wheels, or four rows of two. The latter arrangement would perhaps tend to create two deep wheel ruts, whereas the former would have distributed the weight of the tower more evenly across the running surface. The wheels were 2 cubits (0.92m) thick and plated with iron. We know that a *helepolis* built for Demetrius three years earlier at Salamis, on Cyprus, had only four wheels, each 8 cubits (3.7m) high, and larger wheels will generally have made for easier movement, but there is no reason to suppose that the Rhodes machine also had 8-cubit wheels. Diodorus alleges that sideways movement was possible, but it remains a mystery exactly how this would have been accomplished.

The *helepolis* itself was divided into nine storeys, each of which had two stairways, one for men moving upwards through the tower, the other for men climbing down, to avoid congestion. Athenaeus says that it was 90 cubits (39.9m) in overall height; Vitruvius's measurement is again short at 125ft (37m), and Plutarch's figure of 66 cubits (29m) is presumably a slip for 96 cubits (42.6m). Again, Diodorus gives much more information, reporting that the corner timbers were 'almost 100 cubits long', but instead of standing vertically they tapered in towards the top. Such a structure would have stood around 40m high, like Demetrius's previous nine-storey *helepolis* at Salamis.

Each level had shuttered windows opening to the front, through which a variety of missiles could be fired. The shutters were apparently padded with wool-stuffed rawhide, like mattresses, to absorb the shock of enemy artillery fire, and, although it is likely that they opened outwards, it is not clear whether they were hinged at the top or at the bottom.

The bottom storey of the Salamis tower, which was only marginally smaller than its counterpart at Rhodes, is supposed to have accommodated three-talent stone-projectors; in other words, artillery designed to throw stone balls weighing three talents (78kg). Such machines weighed a colossal amount, and were around 10m long by 6m wide, so there would have been space for only three, side by side; however, the torsion-frame alone was over 4m high, so the operational head-room must have been considerably greater than in a standard siege tower.

The intention was clearly to concentrate heavy firepower at battlement level, where men and masonry were most vulnerable, but the third storey of the *helepolis* was probably already higher than most town walls. There would have been little point in loading artillery in the upper storeys, where its limited angle of depression was a handicap to its functionality, but catapults in the third and fourth storeys could have proved useful at long range. The other floors would have accommodated a variety of missile troops.

The huge quantity of timber used in the machine's construction presented a real fire hazard. Diodorus records that, to offset this, sheets of iron were nailed onto the front and sides. Vitruvius, on the other hand, claims that the machine was protected by padded rawhide, which would certainly have been a lighter and less costly means of fireproofing. But it seems that Vitruvius is again mistaken, as the Rhodians allegedly managed to knock several of the iron sheets off the tower, exposing the timber beneath to their incendiary missiles, whereupon Demetrius had the machine hauled out of harm's way. The rear of the tower was never in any danger, and it would have been most sensible to leave it not only unarmoured, but also completely unboarded, thus providing the interior with much-needed illumination and ventilation.

Although Diodorus, Athenaeus and Plutarch are obviously describing the same machine, Vitruvius's text, taken at face value, specifies an altogether smaller tower. He also diverges from the other

The northern defences of the Attic border fort at Gyphto-kastro. The difficult approach would have hindered wheeled siege machinery. (Courtesy of Deutsches Archäologisches Institut, Athens; neg. no. Attika 238)

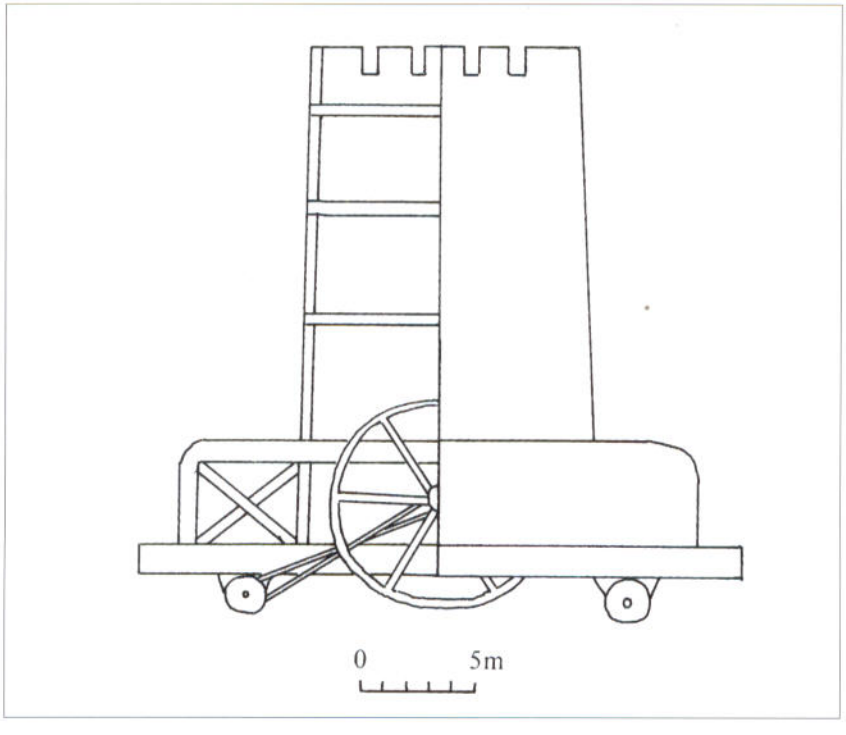
sources in claiming that the machine was fouled in a puddle of sewage which the defenders contrived to pour in its path; apparently, the tower was so heavy that the wheels simply sank in the morass. Is it possible that Vitruvius mistakenly described a different *helepolis*? Certainly, Demetrius is known to have utilised similar machines at Argos in 295 BC and Thebes in 291 BC. Vitruvius's story strikes an interesting chord with Plutarch, who records that the *helepolis* at Thebes was so ponderous that, after two months, the men had managed to drive it forward by only two stades (355m). Was the slow progress caused by Theban sewage?

The method of propulsion

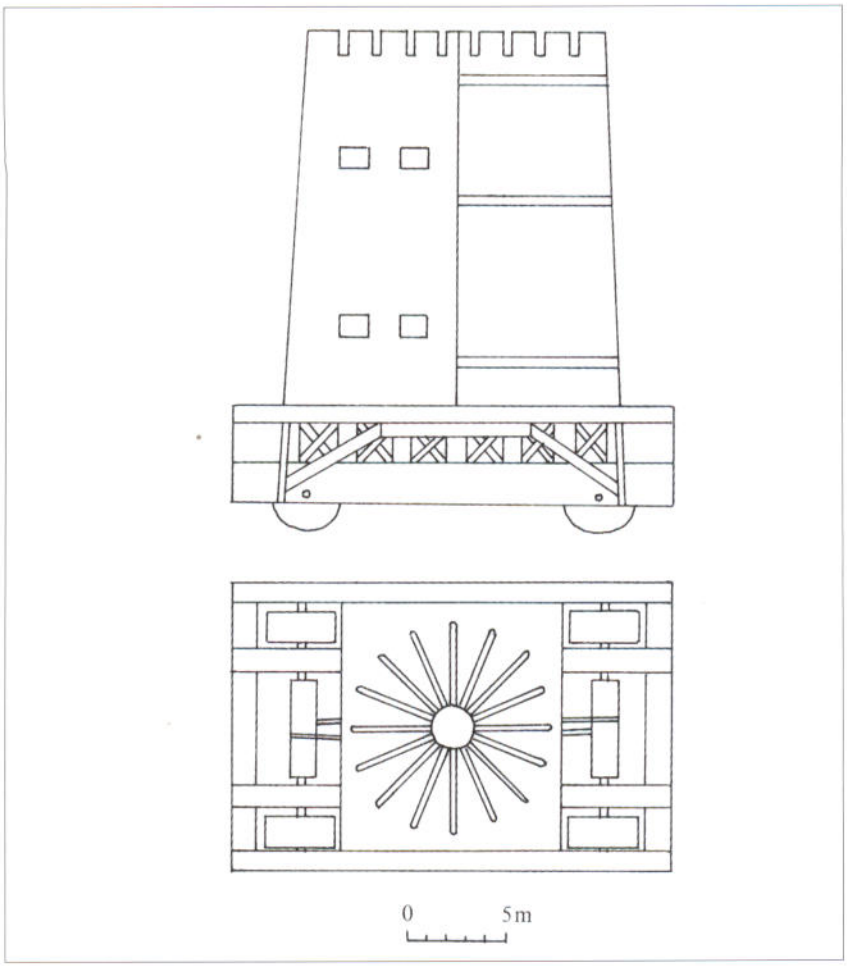
No ancient author indicates the means by which these heavy machines were moved. A passage by Dionysius's contemporary, the author Xenophon, is often claimed to be relevant here. Xenophon records how the Persian Cyrus, in the mid-6th century BC, utilised eight yokes of oxen to drag a 3-storey, 12-cubit (5.55m) tower, with its crew of 20 men. However, this was not a siege tower. It was, in fact, intended for battlefield use, positioned behind, and in support of, the main army; no doubt, after the oxen had hauled the tower into position, they were unhitched and herded out of the firing line. Deploying a siege tower under enemy fire presented quite a different proposition. An effective argument against the conventional use of draught animals is demonstrated by the Goths' siege of Rome in AD 537. Their leader, Wittigis, decided to advance a siege tower against the wall, but the Roman defenders simply shot the oxen harnessed to it while the machine was still some way off, thus instantly neutralising it.

Several of the machines sat on an undercarriage (*escharion*), designed to accommodate the axle-assemblies, as well as incorporating crossbeams for men to push against. However, even in the largest machine, there would not have been enough room to accommodate the thousands who are occasionally mentioned as propelling these vast machines. Of course, the ancients were well acquainted with compound pulleys and winches, and it is tempting to assume that they were used to drag wheeled towers forward.

In fact, the tower built by Posidonius seems to have incorporated something of the sort; according to Biton, it was equipped with 'a place for a windlass ... causing the axles to turn more easily'. Marsden followed Schramm in



Schramm's version of Posidonius's *helepolis*. Schramm tried to follow Biton's instructions literally, but the pair of vertical tread-wheels could never have driven such a heavy machine. (Author's drawing, after Schramm)



Marsden's version of Posidonius's *helepolis*, showing a side view and plan of undercarriage. Marsden adapted Biton's text on the basis of mechanical probability, but the continuous belt-drive is unwarranted. (Author's drawing, after Marsden)

assuming that the windlass must have operated directly on the axles, via a kind of continuous belt-drive. But such a concept probably did not arise until the medieval spinning wheel; even then, it is doubtful whether its application to a siege tower would have been practicable, given the tremendous weight that it was expected to move.

There is an alternative use to which Posidonius could have put his winch. It would have been possible (though this is entirely conjectural) for anchor points to be driven into the ground ahead of the machine, and for ropes to run from these back to the on-board winch; men inside the machine could then have winched it forwards as far as the anchor points. Of course, such a scheme did not necessarily require the winching apparatus to be aboard the *helepolis*, and something similar could have been employed to move any heavy wheeled machine. If the ropes were securely attached to the undercarriage and were run forwards, through pulleys at the anchor points, and back to the rear, a hauling crew (perhaps including draught animals, or utilising winches) could have dragged the machine forwards. The only danger would have been to the men and tackle exposed ahead of the machine, where they were vulnerable to enemy fire.

These massive machines must have moved almost imperceptibly, scarcely advancing by the length of their own wheelbase from one day to the next. Under these circumstances, it would have been sufficient to anchor the pulleys in the ground beneath the front of the machine, and secure the ropes to the rearmost beams of the undercarriage. Then the entire system remained concealed beneath the machine throughout. Of course, any hauling arrangement could have been assisted by a multitude simply pushing against the undercarriage and wide wheels.

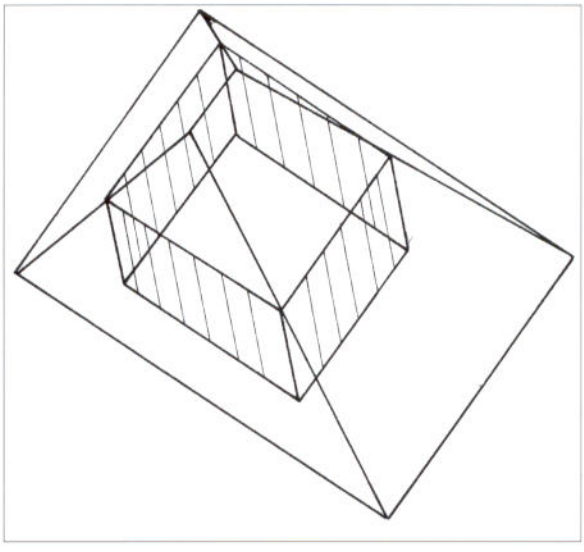
TORTOISE SHEDS

The ditch-filling tortoise

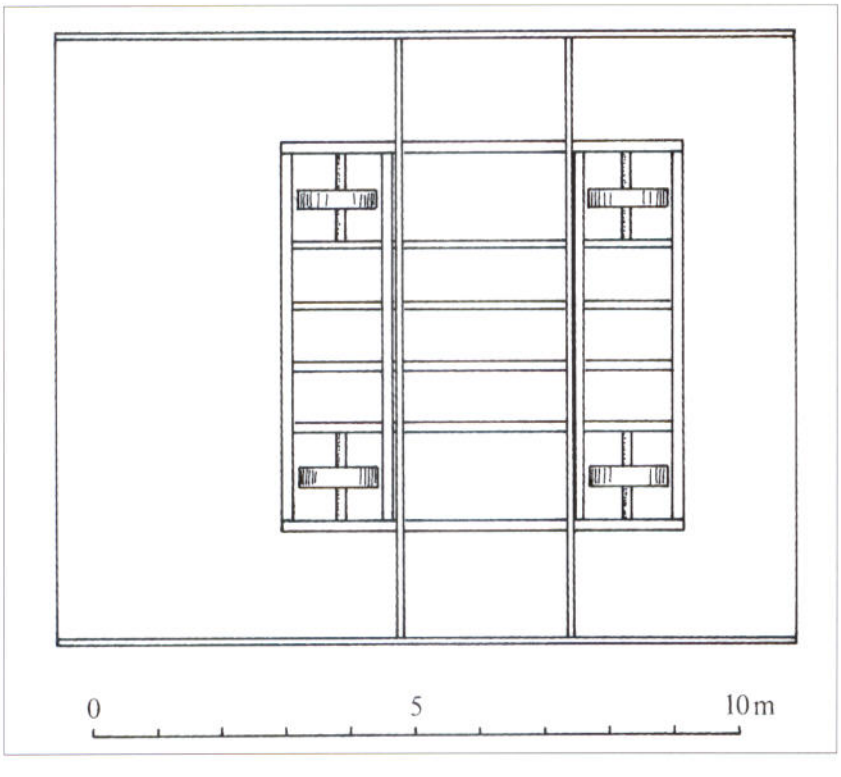
The massive Hellenistic wheeled towers required an approach path that

was smooth, level, and firm. It would have been difficult enough to set the great *helepoleis* in motion, without having to negotiate humps and bumps in the ground. And, as has been seen, such machines were vulnerable to soft ground. In fact, during the attack on the coastal town of Gaza in 332 BC, the wheels of Alexander's towers sank in the sandy soil, so that the undercarriages were damaged and the machines had to be hauled back. In addition, by the mid-4th century BC, many towns had provided themselves with defensive ditches, which needed to be filled if machinery were to be wheeled up to the walls. In the Greek world, artificial ramps of the sort favoured by the Romans were virtually unheard of, but it became usual for men to level out the terrain in advance of the heavy machinery.

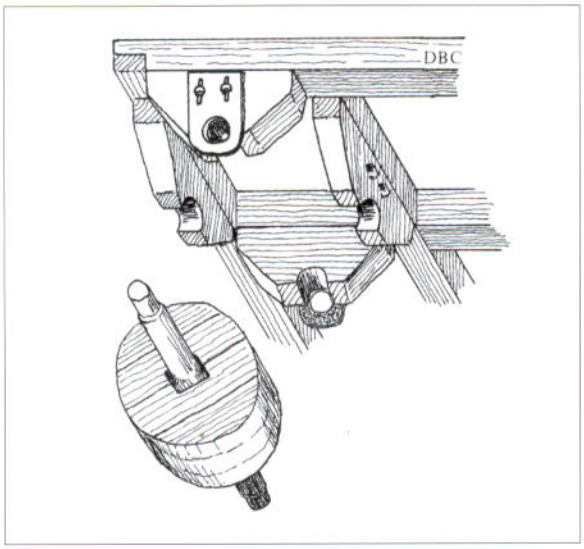
Naturally, they required some form of protection that could be moved forward with them as they advanced, and which would permit them to work unhindered. The solution was the ditch-filling tortoise (*testudo*, or *chelōnē chōstris*), a type of shed resembling a pitched roof on wheels. These machines were cleverly designed so that any projectiles would simply glance off and roll away; they were also protected by the usual fireproof layer. Diodorus Siculus mentions such machines deployed during Alexander's siege of Halicarnassus in 334 BC, and Demetrius later used eight of them at Rhodes, to prepare the way for his *helepolis*; similar machines were still in use a century later by Macedonian and Seleucid armies.



The basic constructional scheme of the tortoise, showing the function of the central compartment in supporting the pitched roof. There is room for a 'middle floor' above this compartment. (Author's drawing)



The ground plan of Athenaeus's ditch-filling tortoise shows the central square undercarriage (*escharion*), internally divided lengthwise by four timbers and breadth wise by two timbers. Another two project to the sides, where a pair of longitudinal outriggers support the ends of the rafters. The corner-squares accommodating the wheels can clearly be seen. (Author's drawing)



In the ditch-filling tortoise, each side of the corner-square has a cradle-like component, which Athenaeus calls a 'wagon-foot' (*hamaxipous*), and each wheel has its own short axle. At any one time, the axle sits in two opposing 'wagon-feet', so that it either faces forwards or sideways. (Author's drawing, after Sackur)

Athenaeus describes how the machine was built around a 7-cubit-high (3.10m) central compartment, sitting on a 14-cubit-square (6.21m) undercarriage (*escharion*). The pitched roof, which was the machine's main feature, extended a further 4 cubits (1.77m) to either side. However, rather than terminating in gable-ends, it also sloped to the front and rear, the four faces meeting in a transverse ridge some 7m above ground level.

Athenaeus attributes the design to 'Philon of Athens', which is surely a slip for Philon of Byzantium, whose *Mechanical encyclopedia (Mēchanikē syntaxis)*, compiled in the later-3rd century BC, included works on artillery and on siegecraft. In the latter, he draws a distinction between the 'wicker tortoise' (*gerrochelōnē*) and the 'ditch-filling tortoise' (*chelōnē chōstris*). The 'wicker-tortoise' seems to have been a simple, open-ended shelter of the sort that the Romans called the *vinea*, whereas the 'ditch-filling' version was entirely enclosed.

The 'ditch-filling' tortoise also had massive foot-thick (29.5cm), 3-cubit-high (1.33m) wheels, one at each corner of the *escharion*. The individual axles were incorporated into an ingenious steering mechanism, which allowed sideways movement. Vitruvius's version allegedly enabled the machine to travel, not only sideways, but also diagonally; however, it is not clear how this was accomplished. One common theory, that each wheel was designed to swivel independently like a castor, is unlikely; Vitruvius envisages a wheel-assembly that was adjustable in 45° increments, whereas a castor would be able to swivel continuously.

Athenaeus recommends that the roof be boarded with palm wood, because of its resilience, and covered with green wickerwork. The suitability of palm wood was apparently well known; Philon also mentions it for general use in siege machinery, but recommends an outer skin of iron scales and some kind of padding, too. Certainly, Athenaeus prescribes an overall cushion of rawhide, padded with seaweed or vinegar-soaked chaff, both to absorb the impact of missiles and as a defence against fire.

A variant form of the machine incorporated a battlemented parapet, from which covert observation of the enemy could be carried out. Apparently, the sloping sides extended only as far as the lintel, which must have supported an upper storey. Both authors recommend eight wheels, perhaps to bear the additional weight of the observation crew.

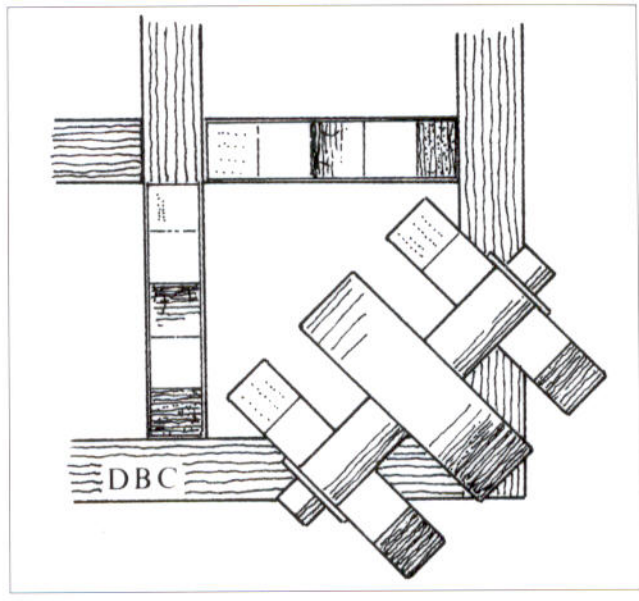
The ditch-filling tortoise covered around 120 square metres of ground. Men would have been able to work comfortably over much of that area, on account of the frame's height above ground, but only practical experiment will reveal exact details of how to move the machine.

The digging tortoise

Both Athenaeus and Vitruvius record a further variation, adapted for

use in close proximity to the enemy wall and differing from the ditch-filling tortoise in one respect only. Rather than the gently sloping front, designed to deflect missiles, it had a vertical front face, to enable it to abut the enemy wall.

Both authors concur that this front face was triangular, implying a longitudinal roof ridge and giving the machine the form of a simple penthouse. Any missiles dropped from the battlements would have rolled off the broad, sloping sides without causing damage. The roof would have been boarded and covered, either with fresh wickerwork and padded rawhide, or with clay mixed with hair. Either method would have provided some degree of fireproofing, and the sloping sides avoided the necessity of cushioning the structure against heavy weights dropped from above.



Sackur made an ingenious suggestion to allow the diagonal movement that Vitruvius mentions. The two outer 'wagon-feet' are made to pivot in the centre, creating a third position for the axle, midway between the forward and sideways positions. (Author's drawing, after Sackur)

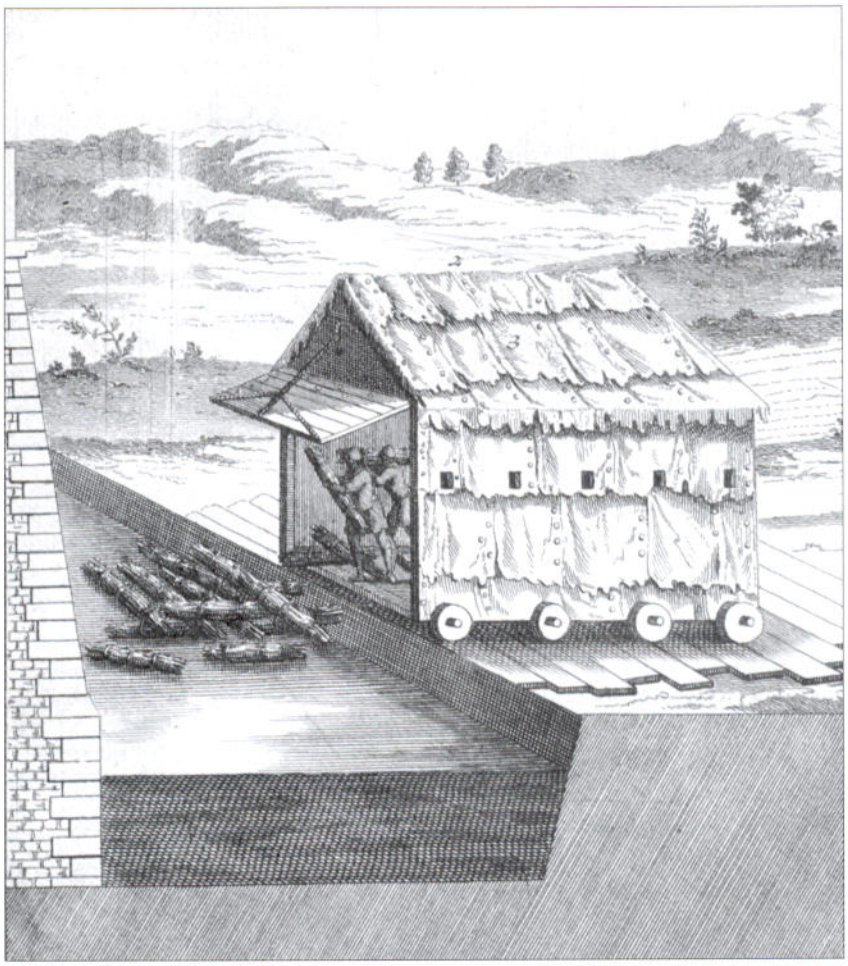
The machine was specifically designed to enable men to work in safety at the foot of the enemy wall. Of course, the front face of the machine prevented its occupants from attacking the wall directly, as some modern writers have assumed, with pick-axes and crowbars. Rather, its structure was designed to permit the men to dig at the foot of the wall, undermining the foundations and destabilising the fortification. Unfortunately, there is no mention of the machine in action in the ancient sources, in marked contrast to its ditch-filling cousin.

The ram-tortoise

Besides crossing over the enemy wall by means of ladders or a siege tower, an alternative option was open to the besieger; namely, breaking through the wall. Most ancient sources simply refer to 'battering rams' during such operations, which has occasionally led to the suggestion that the machine consisted simply of a scaffold, set up at the wall, from which a ramming-beam was suspended. Of course, an unprotected timber framework would not have lasted long in such an exposed location, even if a construction crew could have survived long enough to build it there. In fact, it is clear that, from the mid-4th century BC (if not earlier), battering rams were normally concealed within wheeled sheds, and brought up to their action stations just like siege towers.

The Greek version of the ram-tortoise may even have been the work of Philip's engineer Polyidus, who allegedly developed battering rams that were 'easier to use' at Byzantium in 340 BC. Athenaeus and Vitruvius describe the machine built for Alexander the Great by Diades, a pupil of Polyidus. Like the ditch-filling and digging sheds, it more or less resembled a penthouse on wheels, and was similarly designated as a 'tortoise' (*testudo*, or *chelōnē*).

As with his siege tower, Diades apparently had a small version and a large version, but measurements are given only for the latter. Its overall



De Folard's reconstruction of the ditch-filling tortoise was accepted by generations of scholars. However, several elements of his machine are vulnerable to counter-attack, particularly the exposed wheels. (Author's collection)

dimensions were 30 cubits (13.30m) wide by 40 cubits (17.74m) long, and the apex of the pitched roof stood 16 cubits (7.10m) high; the whole structure was covered with rawhide. Unusually for a tortoise, a three-storey turret crowned Diades's machine. That, and an ambiguous reference to an intermediate floor within the shed, has led to much scholarly confusion.

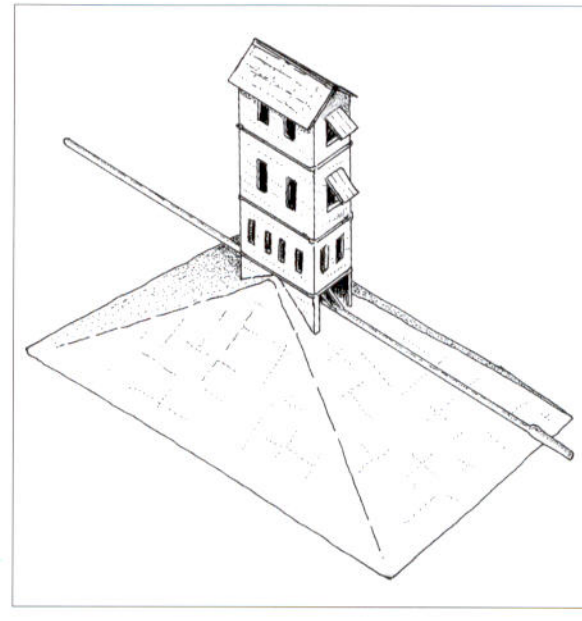
The most likely interpretation of Athenaeus's text (in conjunction with Vitruvius's more summary version) results in a machine very similar to the ditch-filling tortoise. Like it, the ram-tortoise would have been based upon three key elements: the rectangular, wheeled undercarriage; the main internal compartment; and the familiar hipped roof. The enigmatic 'middle floor' will then have been the area between the main compartment and the roof ridge, occupying the same position as the battlemented parapet in the variant form of ditch-filling tortoise. No doubt, it was instrumental in allowing access to the turret, which rose through the apex of the roof.

The upper levels of the turret accommodated 'scorpions and catapults', while the lowest level held a reservoir of water to extinguish any fires caused by incendiary missiles. Vitruvius adds the useful detail that the turret was 4 cubits (1.77m) wide. The term 'scorpion' usually denotes an arrow-firing catapult of smaller calibre; the largest catapult still qualifying as a 'scorpion' was perhaps a machine capable of firing a 70cm arrow (equivalent to 3 spans). The stock of such a machine was about 1.20m long, and, although the torsion-frame was only 0.50m wide, each arm protruded about half as much again, giving an overall width of 1m.

We should not underestimate the amount of working-room required by the artilleryman, particularly at the rear, where the catapult arms were winched back, but also at the sides, where the stock would swing round when the weapon was traversed. It would not be far wrong to assign a 3-span arrow-firer a minimum floor-space of 1.5m x 2.5m. Consequently, it would have been impossible to station more than one catapult in a room 4 cubits wide. Furthermore, the turret must

have been considerably longer than it was wide, to suit the dimensions of a catapult, and it would seem sensible to assume a length of 6, or even 8, cubits (2.7–3.5m).

Of course, the tortoise was simply a mobile platform for the 'ram-holder' (*kriodochē*, or *arietaria machina*), upon which the battering ram rested. This obscure component apparently took the form of a cylindrical roller, which was probably mounted transversely within the framework of the turret; in fact, it would go some way towards explaining the function of the 'middle floor' if the 'ram-holder' were located there. Vitruvius clearly states that the ramming-beam sat on the 'ram-holder' and was set in motion by pulling and releasing ropes. It seems a somewhat precarious mounting for a heavy ramming-beam, and part of the mechanism is perhaps missing from the description.



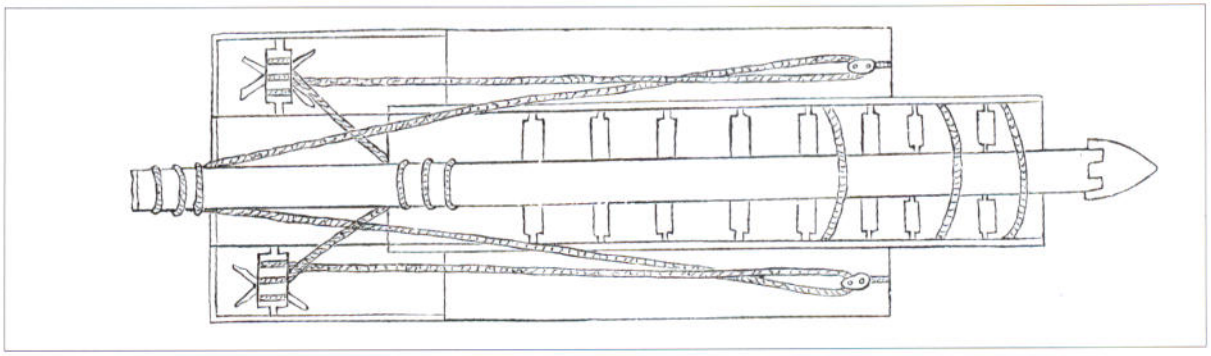
Suggested reconstruction of the ram-tortoise of Diades. The design of the turret is conjectural. (Author's drawing, following Lendle's interpretation)

Locating the beam 6m above ground level has interesting implications for the ramming process. Clearly, Diades did not intend to breach the enemy wall at its foot, where the foundations could be expected to have been more solid. Nor was he aiming at battlement level, which may have been as high as the 20 cubits (9.25m) recommended by Philon, or even higher (though the alleged height of 40 cubits for the walls of Piraeus has been doubted). Rather, the target seems to have been a midway point, guaranteed to weaken the wall-walk above, thus preventing any counter-measures. Defenders commonly disrupted ramming operations by dropping heavy weights onto the ram head or ensnaring it with lassos, both of which required a vantage point directly above the ram. Perhaps Diades incorporated some method of adjusting the angle of the ramming-beam, in order to continue the breach downwards, to a height at which infantry could enter.

The 'borer'

For breaching the wall at its foot, Diades employed a different machine; Athenaeus and Vitruvius claim that it was called a 'borer' (*trypanon*, or *terebra*), although it did not use the same drilling action as the carpentry tool of the same name. In outward appearance, it resembled the ram-tortoise, perhaps even including the artillery turret, which would have been a useful adjunct for any machine working in close proximity to the enemy wall. Internally, it would have been based upon a rectangular, wheeled undercarriage, of the sort familiar from the other tortoises, but the long, iron-pointed beam, which gave the machine its name, employed a different mechanism from the *kriodochē*, or 'ram-holder', of the ram-tortoise.

This time, the ramming-beam ran along a grooved timber (*syrinx*, or *canalis*), which, Vitruvius adds, was 50 cubits (22m) long and 1 cubit (0.44m) high and was mounted on supports. As both authors point out, the same word is also used for the groove of a catapult, in which the arrow is laid in order to guarantee a straight shot; incorporated



Diades's borer. In this medieval manuscript illustration, the artist has arranged the tackle as if the beam were winched forwards, but it is unlikely that sufficient force could have been generated by this means. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

in this machine, it ensured that the ramming-beam hit the same spot, time after time. In addition, it was equipped with a winch at the rear, again as on a catapult. However, unlike the catapult, the borer's groove was fitted with a series of rollers along the bottom, so that the ramming-beam would easily roll backwards and forwards.

It will have been a simple matter to winch the beam backwards. Driving it forwards with enough energy to break through a wall is quite a different matter. However, for this purpose, another two rollers were positioned towards the front end of the groove, one on either side. Traction ropes, attached to the rear of the ramming-beam, will have been run forward, around these rollers and back towards the rear, so that hauling-crews inside the tortoise, positioned to left and right of the groove, could pull the beam forwards with a violent tug.

Both authors add that the beam 'and the arches' were covered with rawhide, just like the tortoise. The clue to the possible identity of these arches comes when we compare the length of the groove with the length of Diades's tortoise, because it is clear that the former will have projected up to 10 cubits (4.4m) beyond the latter. This exposed section must have been arched over to give it some protection from above, but even then it would have been particularly vulnerable to missiles dropped from above. Thus, covering fire would have been essential, either from an integral turret or, at longer range, from the rear, in order to keep the battlements clear of defenders and ensure that no countermeasures could be launched.

Hegetor's ram-tortoise

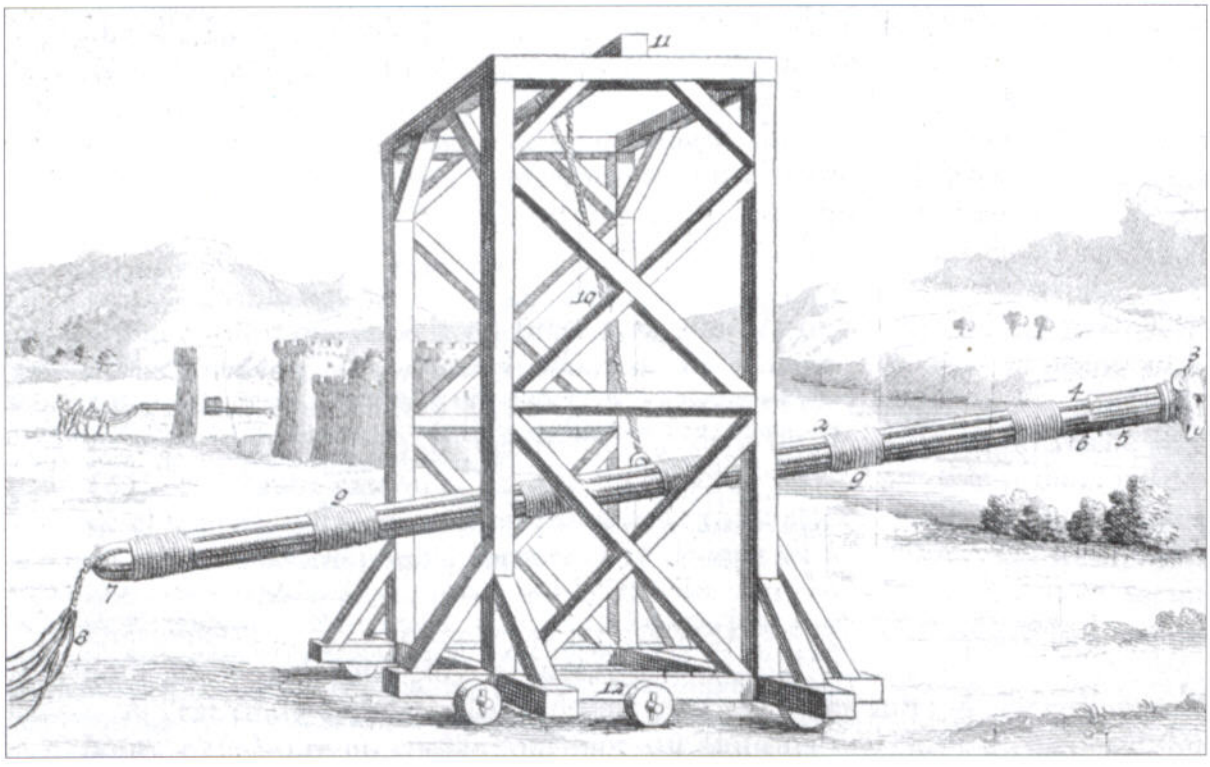
Diades's ram-tortoise and borer were apparently constructed for Alexander the Great, which places them in the 330s BC. Athenaeus and Vitruvius both preserve details of a different ram-tortoise, devised by an otherwise unknown engineer named Hegetor of Byzantium. It has been suggested that Hegetor worked for Demetrius Poliorcetes, who had a penchant for grandiose machinery, though the connection is more than a little tenuous. The historian Diodorus Siculus records that, during the siege of Salamis, Demetrius 'constructed enormous battering rams and two ram-carrying tortoises', and that, at Rhodes, his two ram-tortoises were 'many times larger' than the ditch-filling tortoises that preceded them. Their ramming-beams are said to have been 120 cubits (53.2m) long, the very length that Athenaeus attributes to Hegetor's battering ram, but the practicality of such a long beam has been questioned.

Athenaeus claims that Hegetor's 120-cubit ram was rectangular in cross-section, and tapered from a rear end 2ft (59cm) 'thick' (by which he must mean the 'height' of the beam) and 1¼ft (37cm) broad, to a tip 1ft by ¾ft (29.6cm x 22.2cm). Vitruvius gives a completely different set of dimensions: the length, he says, was 104ft (30.75m), and the rear end was 1¼ft by 1ft (36.9cm x 29.6cm), tapering to 1ft by ¾ft (29.6cm x 22.2cm) at the tip. (The anonymous Byzantine muddies the waters by combining Athenaeus's statement of length, with Vitruvius's dimensions for the thickness of the beam.)

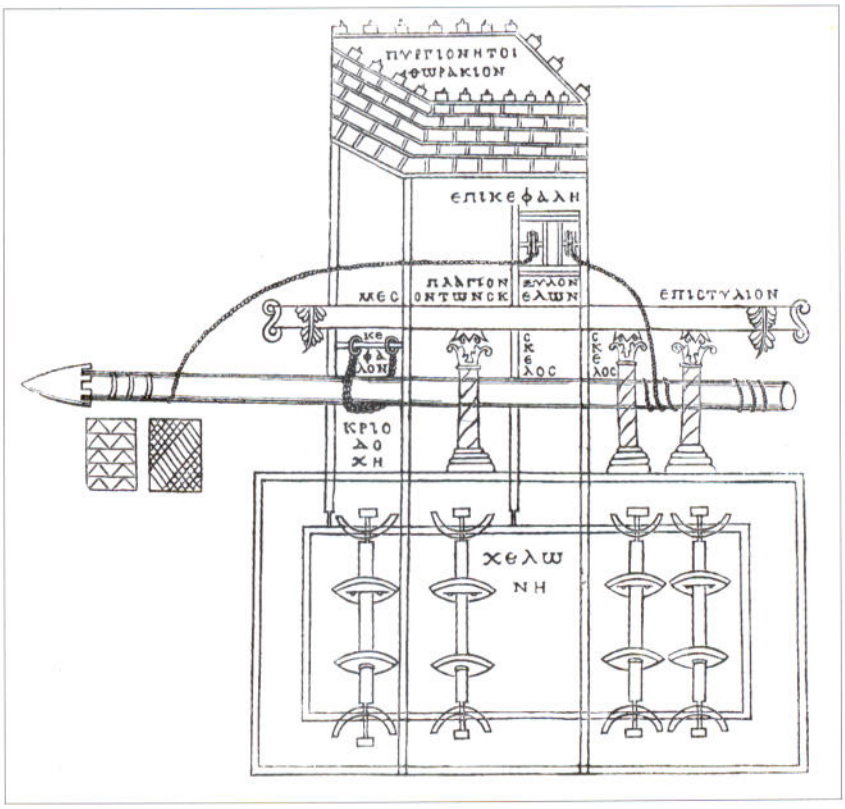
Schramm believed that a 50m beam would buckle, and the ends would drag on the ground, making the whole contraption unusable. He proposed that Athenaeus's text should be emended to read 120ft (35.5m), considerably shorter than 120 cubits, but still some way from Vitruvius's figure. (The alternative approach adopted by the Greek scholar Sir William Tarn, who postulated that a special 'short' cubit of around 34cm was used in Macedon, takes us even further from Vitruvius.)

A better solution, which actually goes some way towards reconciling the two sources, is to assume that the Greek text of Athenaeus has been corrupted during transmission down through the ages, and that an original statement of '70' (*hebdomēkonta*) cubits was miscopied as '120' (*hekatoneikosi*) cubits. A length of 70 cubits (31m) is very close to Vitruvius's measurement. (Precisely how Diodorus came upon the measurement of 120 cubits for Demetrius's battering rams remains unknown; perhaps both he and Athenaeus drew upon a common source, which had already become corrupted by their day.)

The ramming-beam was capped with an iron tip, like the beak of a warship. Basically, this was a hollow lump of iron, designed to fit over the



De Folard's reconstruction of the battering ram. It is unlikely that a single suspension point would enable the ram to work effectively. However, the ramming-beam itself is a fairly accurate representation. (Author's collection)



Hegetor's ram-tortoise. This illustration, dating to the 11th/12th century, combines several viewpoints, and demonstrates a convention that is often found in manuscript diagrams. The artist has attempted to show a perspective view of the turret, superimposed on a plan of the undercarriage, while the ramming-beam is shown in a simple side elevation. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

end of the beam, but it was secured by four ten-cubit (4.4m) iron strips, which trailed back along the beam like streamers and were nailed into position. (Vitruvius calls these streamers *lamminae*, which is the usual term for a strip of metal, but Athenaeus calls them 'iron spirals', implying that they were wound around and along the beam.) The beam was further reinforced with ropes, using a technique well known in the ancient world for bracing the hulls of ships, and completely wrapped in rawhide, a necessary protection against fire because it was entirely exposed above the level of the tortoise.

The tortoise itself was similar in size to Diades's model. Athenaeus gives the dimensions as 42 cubits (18.62m) long and 28 cubits (12.42m) wide. Vitruvius's version, at 60ft by 13ft (17.7m x 3.8m), is obviously wrong, and is usually corrected by emending the manuscript 13 (XIII) to read 42 (XLII); 42ft is the equivalent of 28 cubits, and thus matches the width quoted by Athenaeus. Vitruvius's length of 60ft is 3ft short of Athenaeus's 42 cubits, but this may also be a manuscript error.

The machine ran on eight wheels, $4^1/_2$ cubits (1.99m) high and 2 cubits (0.88m) thick, which, according to Vitruvius, comprised three layers, each 1ft thick, pegged together with dowels and fastened with iron bands. (Here again, Vitruvius uses the word *lamminae*.) Unfortunately, as with that other eight-wheeled machine, the *helepolis* of Epimachus, we are not told the configuration of the wheels, but positioning them four abreast would distribute the massive weight of the machine more evenly. Also, a machine built to Athenaeus's dimensions and following the principles of the ditch-filling tortoise would have rested upon an undercarriage some 16 cubits (7.10m)

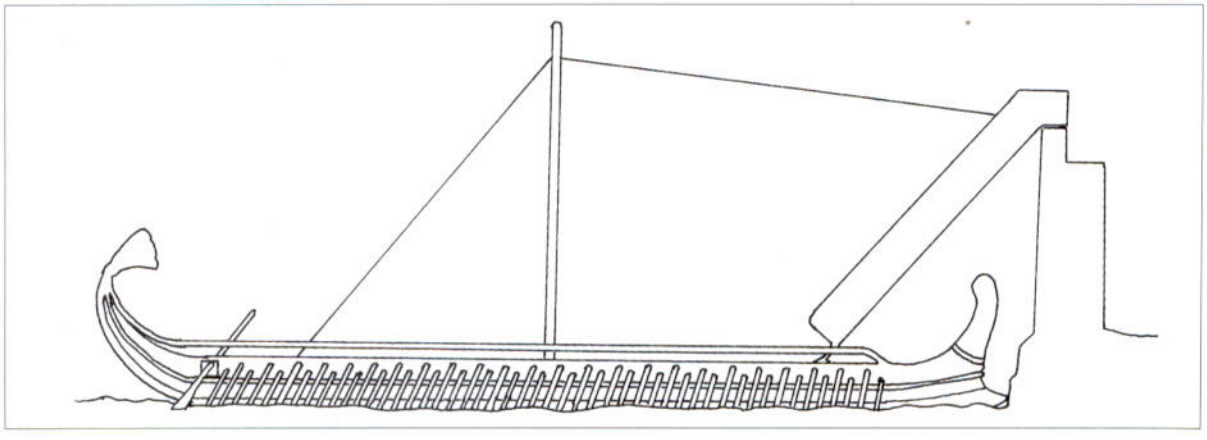
square; consequently, there would not have been space for four in-line wheels, and they must have been arranged four abreast.

Like the ditch-filling tortoise, the ram-tortoise would have had a hipped roof meeting at the top in a transverse ridge. The whole machine could then be boarded over and covered with a fireproof layer. As with Diades's ram-tortoise, this style of construction resulted in a 'middle floor' (*mesē stegē*, or *media contabulatio*), which has caused such confusion amongst those attempting to reconstruct the machines. In the case of Hegetor's tortoise, this second storey had floor space of 16 cubits (7.10m) square, and headroom of 8 cubits (3.55m) up to the roof ridge. Athenaeus says that it accommodated an artillery position (*belostasia*), and Vitruvius explains that scorpions and catapults were located there. Firstly, this contrasts with Diades's version, where the artillery occupied a three-storey turret, rising above the middle floor; and secondly, it implies that there were windows through which the catapults could fire. This seems an altogether more practical arrangement than Diades's rather fragile and cramped turret.

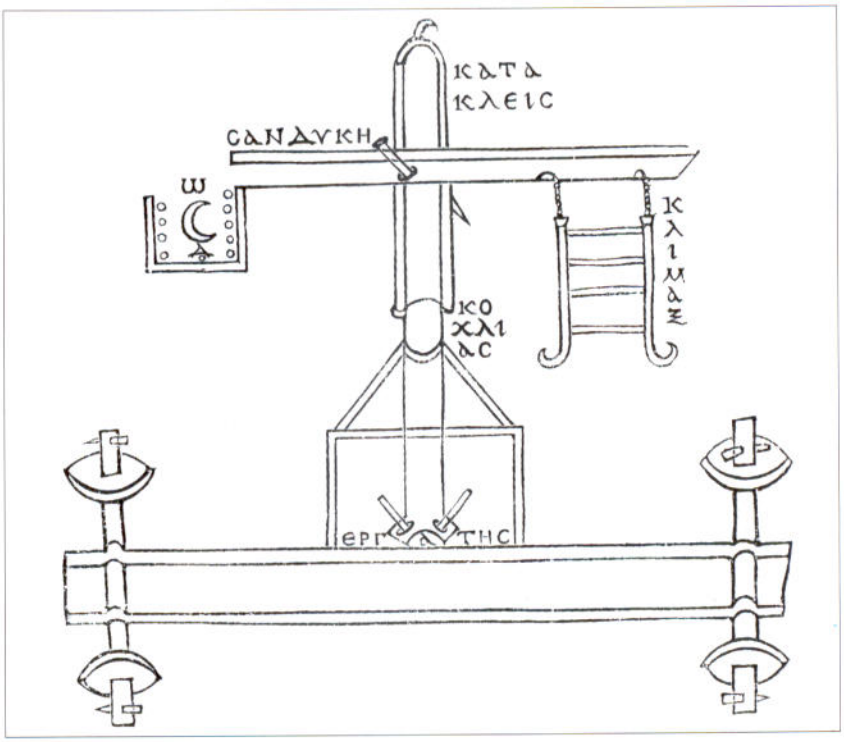
But even though Hegetor deployed the necessary supporting artillery in the middle floor, he did not entirely dispense with a central turret. According to both Athenaeus and Vitruvius, the working of the ram somehow depended upon a frame, which rose through the middle floor to project some 4m above the roof ridge, and incorporated a crow's-nest at the top.

The potential firepower of the tortoise can be estimated by comparing the middle floor area with the space requirements of small- to medium-sized catapults, but both the sloping penthouse construction and the timber uprights of the turret must be taken into account. The first would have limited the useable area to the very middle of the floor, and the second divided this area across the middle. The rear was best reserved for ladders, allowing the crew to move from the under-carriage up into the turret, leaving just enough space in front (around 3.7m wide by 2.7m deep) for three 3-span arrow-firers, side by side.

The construction of the turret is not explained and we must resort to conjecture. The sources mention four robust, 24-cubit (10.64m) uprights, and another two 30-cubit (13.3m) uprights. The latter pair supported a device consisting of two rollers, sitting side by side. In the words of Vitruvius, 'the ropes which held back the ram were fastened



In assaults on maritime fortifications, large warships were often lashed together in pairs to carry siege machines. Polybius describes how the Romans attempted to use mechanical assault-ladders (*sambucae*) like this at Syracuse, but were prevented from approaching the walls by Archimedes' artillery. In 88 BC, a similar machine collapsed during an attack on Rhodes by Mithridates of Pontus. (Author's drawing)



Damios's *sambuca*. The manuscript illustration, dating to the 11th/12th century, was probably not based on Biton's original diagram, but was a later attempt to make sense of his text. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

around these [rollers]'. However, this is not the ram-holder itself (*kriodochē*, or *arietaria machina*); that component, as both authors explain, lay somewhere in front of the double rollers. In addition, whereas Diades's battering ram seems to have rested upon the ram-holder, Hegetor's ram was suspended in the middle by a thick hank of ropes.

The German scholar Otto Lendle has devised the most plausible interpretation of this enigmatic structure. The ram-holder, being the suspension point for the ramming-beam, would have been centrally located in order to distribute the weight most efficiently, and Lendle fixes it between the four uprights of the turret. At this point, there would have been less than 2m clearance above the roof of the tortoise, so the suspension-tackle must have been relatively short, to prevent the ramming-beam from snagging on the roof ridge.

It has been conjectured that the ropes running from the rollers were in some way instrumental in altering the height of the ram head, and indeed both Athenaeus and Vitruvius suggest that the enemy wall could be battered up to a height of 70 cubits (31m). This is an extraordinary claim, given that the battering ram was suspended only about 26 cubits (11.5m) above ground. In any case, 70 cubits greatly exceeds the usual range of fortification heights; even operating horizontally, the beam would have been higher than most town walls. Sadly, neither author gives any idea of how the battering ram was operated. The necessary pendulum motion would have required some means of pulling the beam backwards, and there were perhaps several ropes attached to its rear end, to be pulled by hauling crews on the ground. Furthermore, the length of the beam's suspension would have restricted it to short blows. It is not clear how successful this

method would be if the beam were set at any angle other than the horizontal, and it must be admitted that many aspects of Hegetor's ram-tortoise remain a mystery.

ANCILLARY MACHINES

The siege tower was an expensive alternative to the perils of the assault ladder. Engineers attempted to strike a happy medium, by devising a machine that incorporated the simplicity of the ladder, with the superior protection of the siege tower, and the ease of use of the flying drawbridge. Three different solutions emerged.

The 'seesaw'

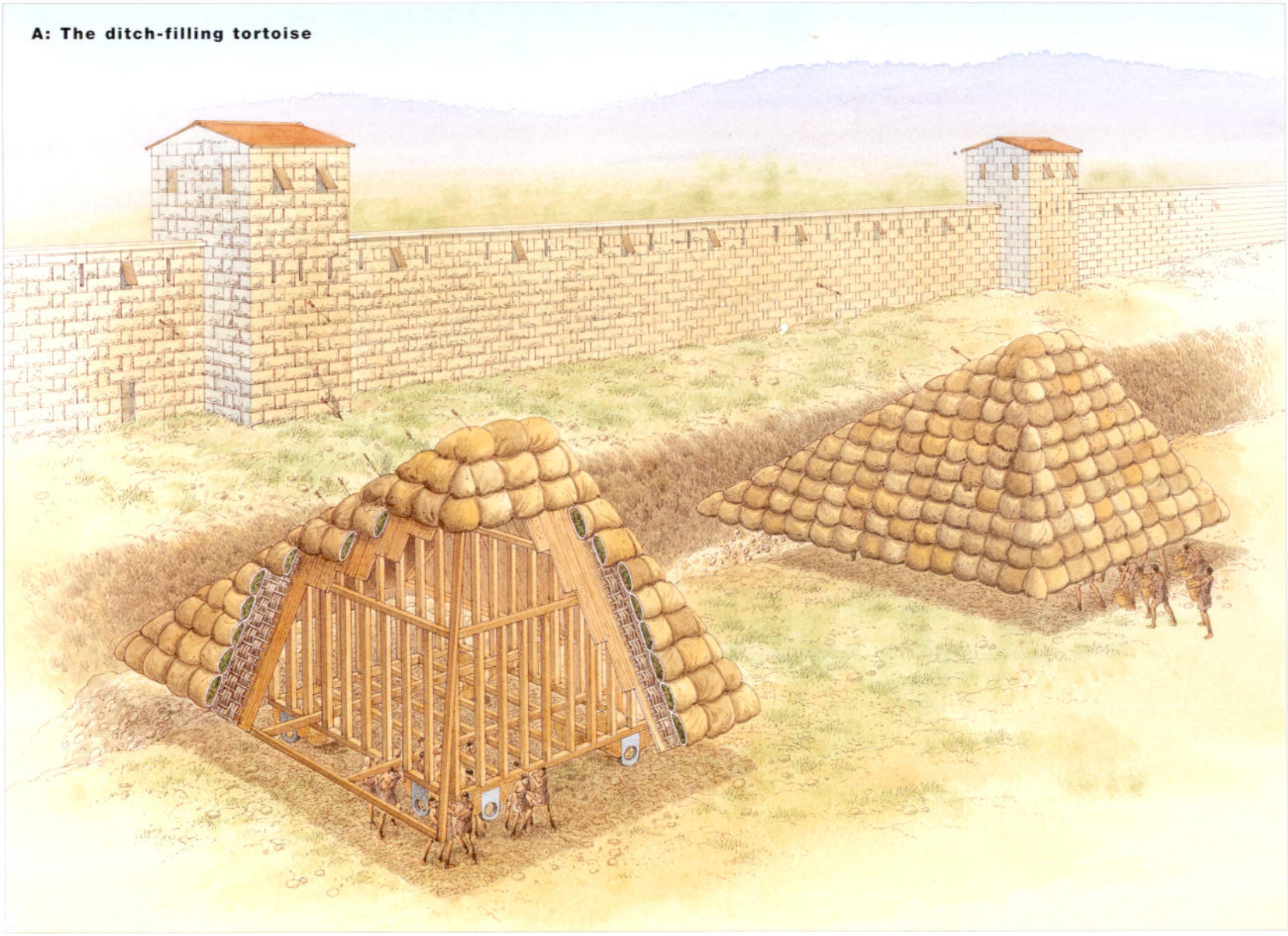
Athenaeus mentions a contraption (*mēchanēma*) designed by Ctesibius of Alexandria, probably working around 270 BC under the patronage of Ptolemy II Philadelphus. He notes, somewhat unflatteringly, that it has no practical value, but that the engineer deserves our admiration for his ingenuity. In essence, a four-wheeled wagon supported an upright frame with a tilting mechanism at the top. Attached to this mechanism at its mid-point was a component that Athenaeus calls the 'pipe' (*syrinx*); the presence of a door at its far end suggests a kind of covered gangway. Athenaeus explains that, when soldiers walked along this gangway they upset its balance, like a seesaw. Clearly, once the machine was wheeled into position, those inside (for it would take more than one man to finely alter the balance) would lower the end onto the enemy wall, throw open the door, and emerge fighting.

The *sambuca*

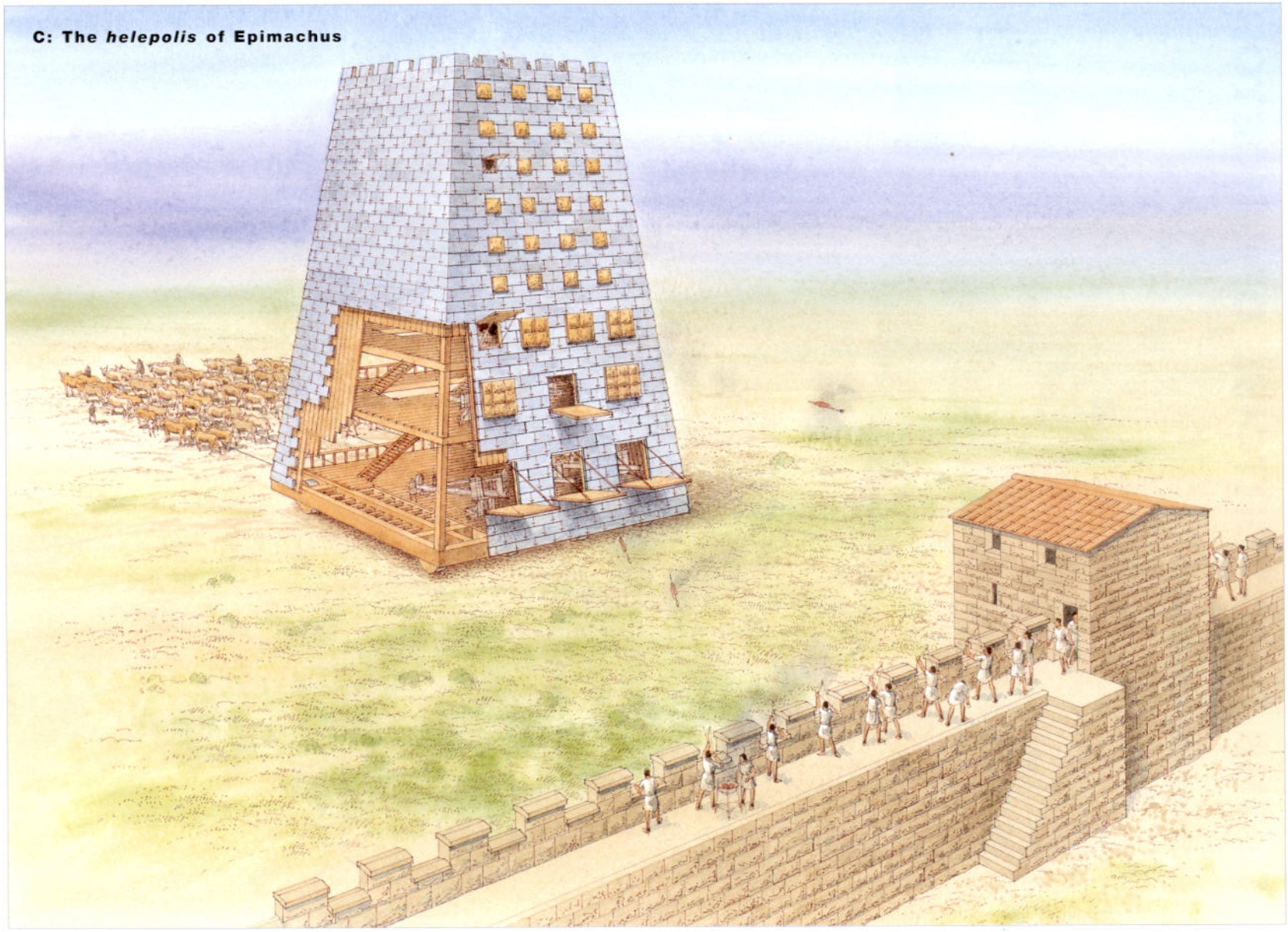
The most famous examples of the *sambuca* (or *sambykē*) were mounted on board ships, where they resembled giant laddered drawbridges for transferring marines onto the sea walls of coastal towns. However, the *sambuca* that Biton attributes to Damios, an otherwise unknown engineer from Kolophon in present-day Turkey, is quite different. First, it was designed for use on land, and second, it utilised an innovative vertical screw to alter the elevation of the ladder.

The shape of Damios's machine has engendered a certain amount of controversy. Biton says that the *sambuca* itself, a 60ft (18m) ladder with an assault platform at one end and a counterweight at the other, sat on a 'trestle' (*killibas*); the trestle was fixed to a 27ft (8m) undercarriage, equipped with 3ft-high (0.9m) wheels. The vagueness of the description has given scholars ample room to indulge their imaginations, but Marsden's model, consisting of a single beam supporting a tall upright, would have been far too precarious for practical use. Schramm's wide, rectangular undercarriage would have given more stability, but he mistakenly designed the ladder as a single beam with rungs projecting on either side.

Biton's ladder clearly has sidewalls, 'so that the men climbing up will make the ascent confidently', and a widened jumping-off area at the top. In fact, it probably resembled the shipboard version, described by the historian Polybius in the 2nd century BC. He says that 'a ladder is prepared, 4ft (1.2m) wide, in such a way that it reaches the wall from its position; each side is fenced and covered with a high breastwork ...


A: The ditch-filling tortoise

B: The *sambuca*


C: The *helepolis* of Epimachus

D: THE RAM-TORTOISE OF HEGETOR

KEY

1 Observation Post. Vitruvius explains that two men should be posted here, to watch out for enemy activity; Athenaeus is chiefly concerned with incoming fire.

2 Rollers. The ropes perhaps altered the height of the ram head, although Athenaeus and Vitruvius both claim that they were to 'hold back' the ramming-beam, perhaps prior to swinging it forward.

3 Ram-holder. The design is hypothetical, as neither author gives a description.

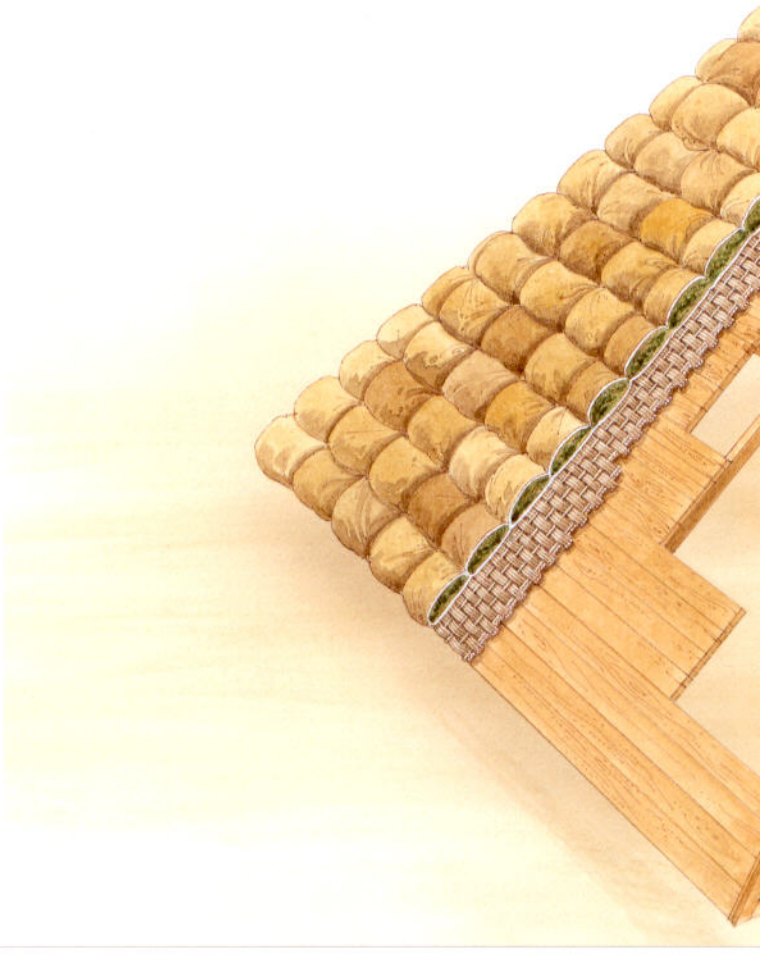
4 Turret structure. Designed to support the ram-holder and take the weight of the ramming-beam.

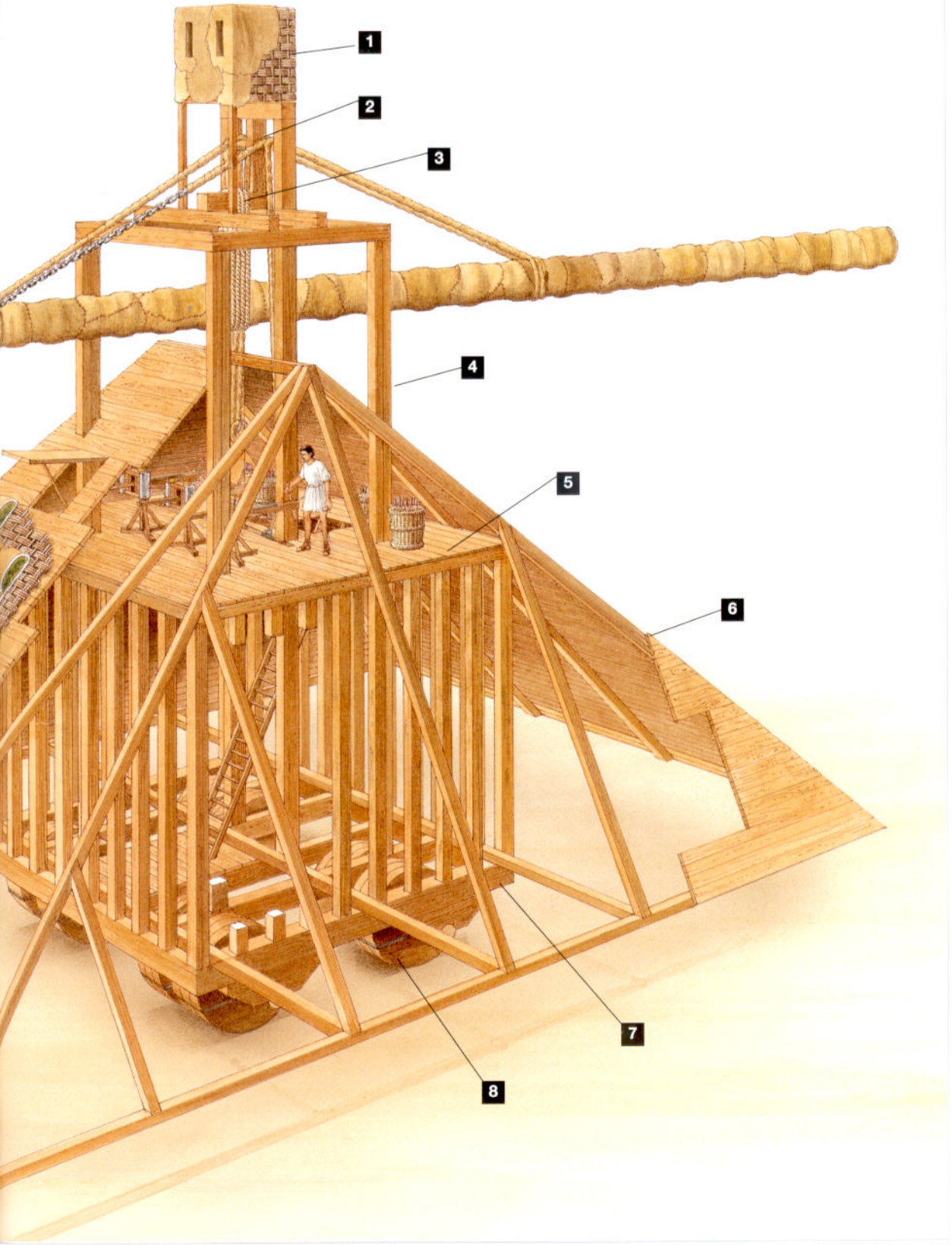
5 Middle floor. Both Athenaeus and Vitruvius indicate its purpose as an artillery loft.

6 Hipped roof. Boarded, padded and fire-proofed, the shelter was designed to minimise impact damage.

7 Undercarriage. The 'grid-iron' design permitted men to push against the transverse timbers to set the machine in motion.

8 Wheels. The three-ply construction, with each plate comprising four dovetailed pieces, braced by iron bands, ensured maximum strength.

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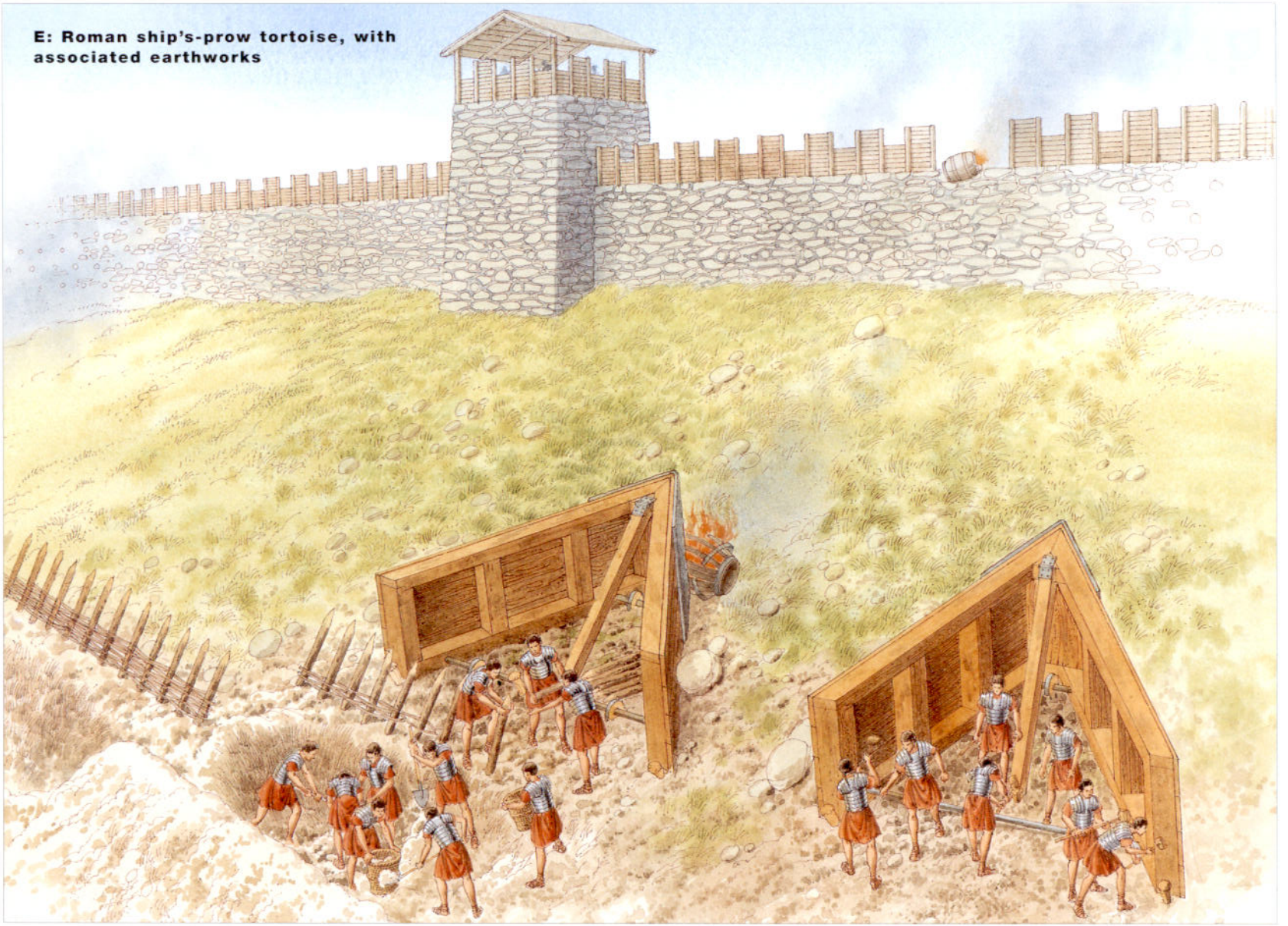
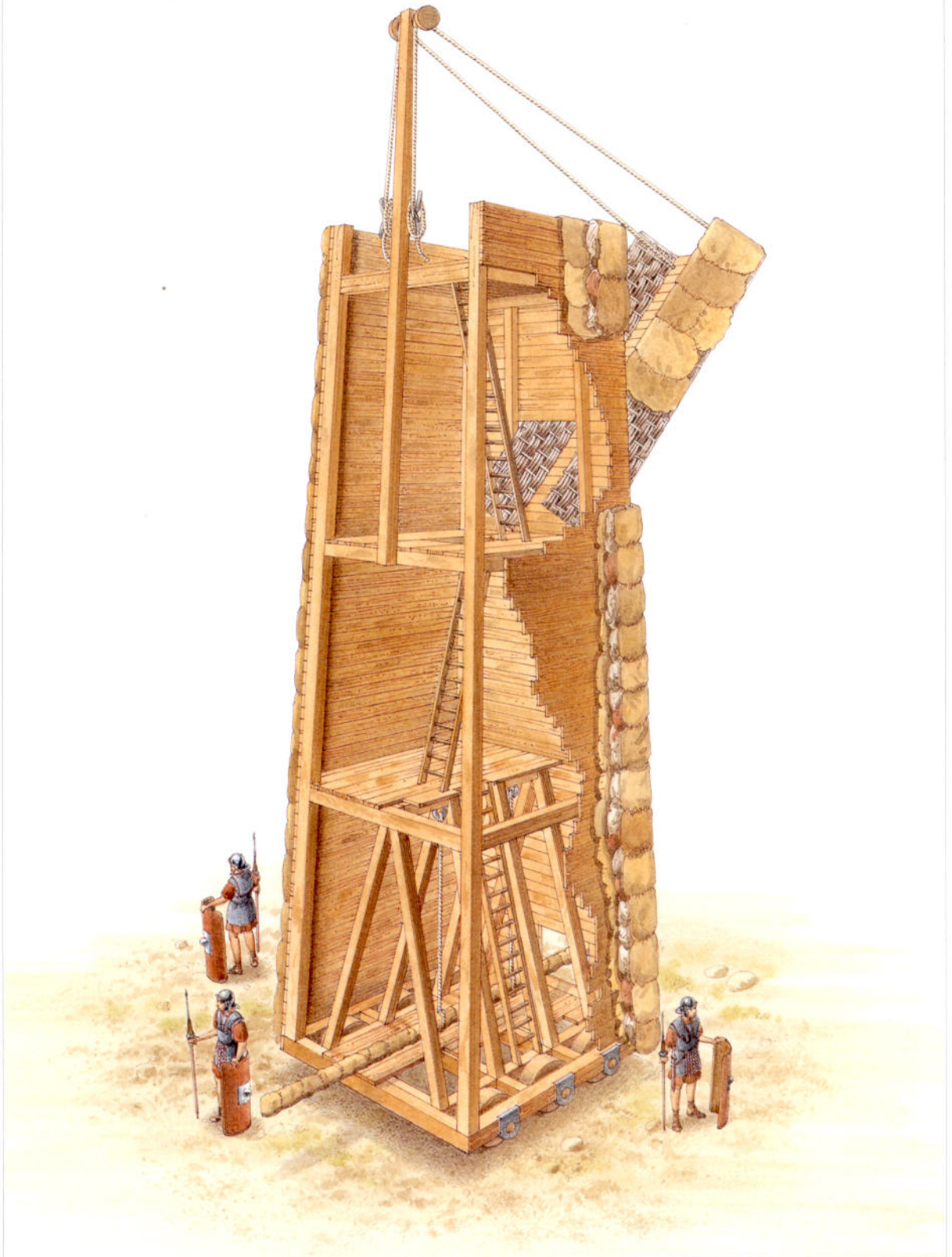
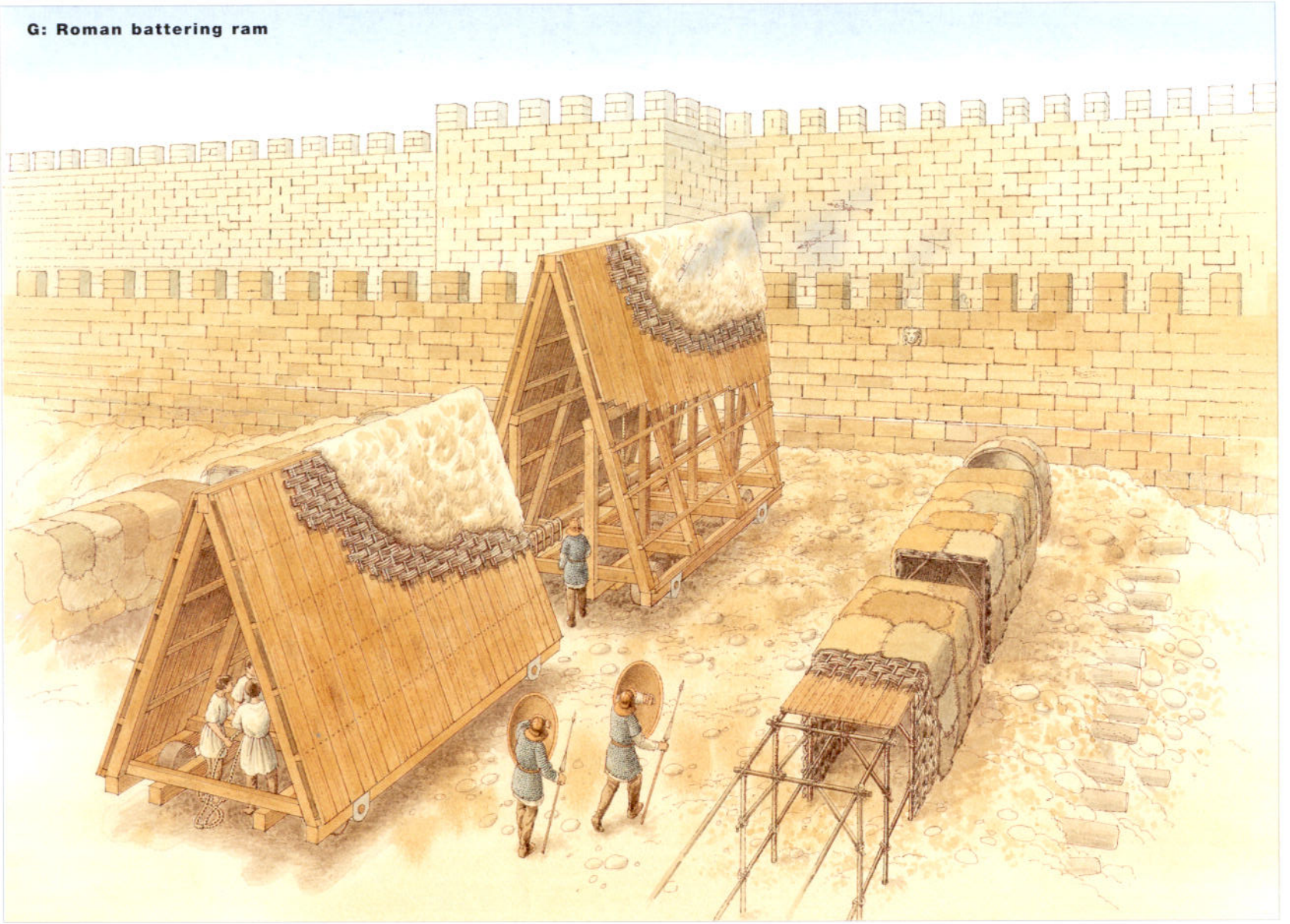

E: Roman ship's-prow tortoise, with associated earthworks

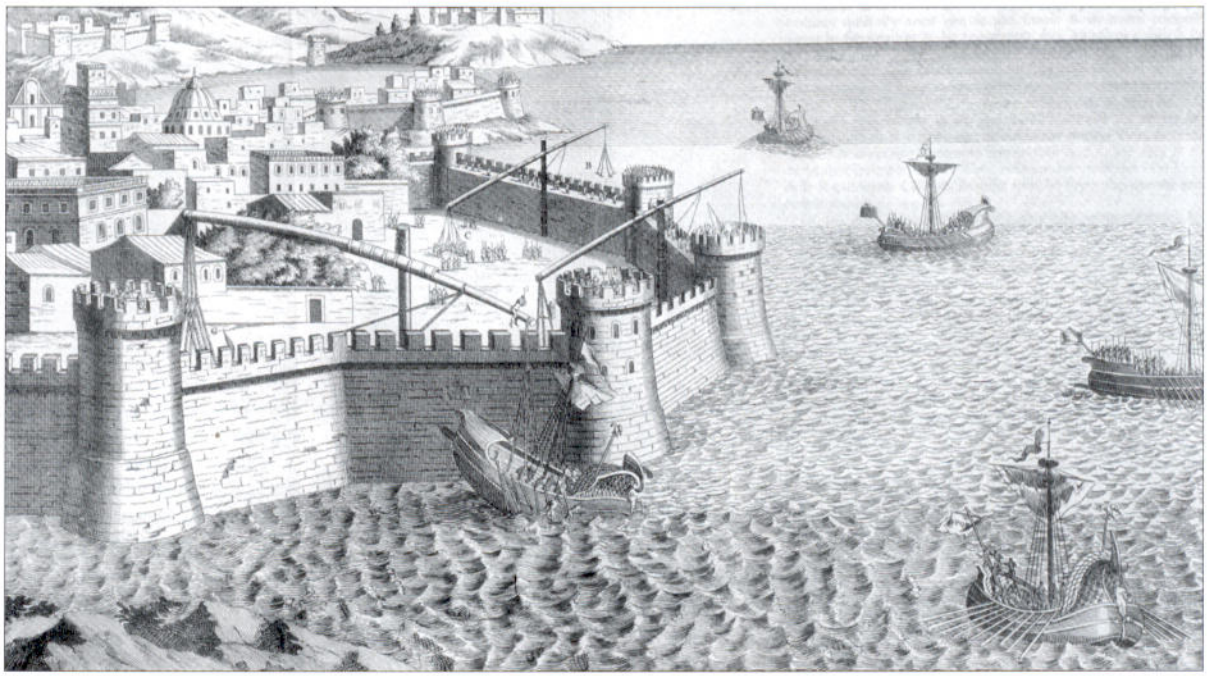
F: Roman siege tower with drawbridge



F

G: Roman battering ram





De Folard's reconstruction of the defence of Syracuse against the Romans in 214 BC, showing the *tolleno* devised by Archimedes, the mathematician and engineer. (Author's collection)

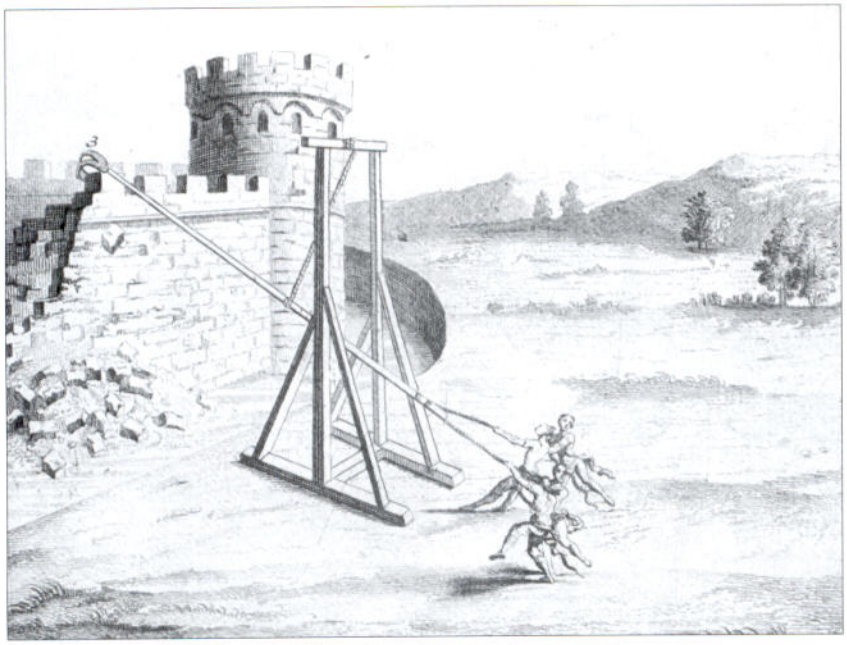
at the top of the ladder is a platform, protected by wickerwork on three sides, on which four men are stationed.' It seems likely that Damios's assault platform had similar protection; with the machine at its action station, the wicker panels were removed and the men rushed out.

Unlike the shipboard version, Damios's ladder had, at the rear, a 6ft-long (1.8m) lead-filled box. Schramm was unsure of its purpose, but Marsden assumed that this counterweight was intended to balance the machine like a seesaw; consequently, he added a horizontal pivot, fixed to the trestle. Drachmann, who pronounced the whole thing 'an armchair invention', highlighted the absurdity of this arrangement, but rather than question Marsden's interpretation, he denounced Biton's work as a sham.

Of course, the ladder was never intended to rock like a seesaw. On the contrary, its movement was regulated by a 15ft (4.5m) vertical screw, running up through the trestle to a component called the 'fastener' (*katakleis*). Biton is a little vague on the workings of these elements, but the ladder, horizontal at rest, was probably hinged to the rear of the 'fastener'; the screw would then elevate the front of the ladder, fine-tuning the height of the assault-platform. The counterweight played no part in this operation, but was required to preserve the machine's stability. Schramm and Marsden both assumed that the ladder projected by at least 40ft (12m); in that case, the short end would have needed ballast of around 2 tonnes to offset the weight of an assault unit of perhaps eight or ten soldiers on the forward platform.

The *tolleno*

A simpler device, employed by besiegers and besieged alike, consisted of a long, horizontal lever with a hinge in the middle, by which it was fastened to the top of an upright timber; when one end was pulled down, the other end swung up. The besieged had ample scope to adapt such a device for



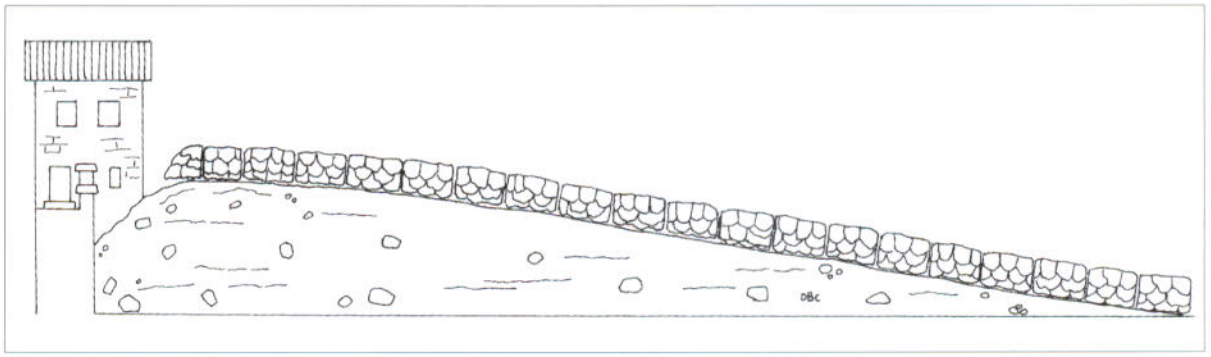
The ancient sources mention defenders using grapnels or 'iron hands', for ensnaring men and siege machinery. Diades is credited with the invention of one of these, the *corvus demolitor* or 'demolition raven', imaginatively reconstructed here by de Folard. (Author's collection)

disrupting the activities of the besiegers, either by catching equipment with a hook or grab, or by dropping heavy weights onto machinery. At Syracuse in 214 BC, Archimedes used the device to jerk the Roman besiegers' ships out of the water, and at Cremona in AD 69 the defenders snatched individual combatants and swung them over the town wall to be dealt with inside. In 429 BC, the besieged Plataeans used a similar machine (the historian Thucydides calls it a *keraia*, 'yard-arm') to drop heavy beams onto the Spartan battering rams, in an attempt to snap off the ram heads; the Ambracians employed the same tactic in 189 BC.

An interesting variant for use by besiegers is described by Vegetius in his *Summary of military topics* (*Epitoma rei militaris*); although written in the later-4th or early-5th century AD, the information on siegecraft is thought to have been lifted from a lost tactical manual (*Tactica*) by the 1st-century writer Frontinus. In Vegetius's *tolleno*, one end of the crossbeam is equipped with a wickerwork basket, large enough to accommodate a few soldiers. With the upright planted near the enemy wall, the basket of soldiers could be swung up onto the battlements in a workable, if rather perilous, manoeuvre.

ROMAN MACHINES

With regards to siege warfare, and therefore siege machines, Roman armies initially took a rather different tack from their Hellenistic neighbours. They favoured the storming escalade, unsupported by heavy machinery, as shown by their siege of the Samnite town of Silvium in 306 BC; at the same time, Demetrius Poliorcetes was terrorising the eastern Mediterranean with his formidable *helepoleis*. No doubt, Roman acquaintance with Carthaginian practice during the Punic Wars of the later-3rd century BC, and with the operations of Philip V of Macedon during the early-2nd century BC, demonstrated the



Many Roman sieges involved the use of an earthen ramp to carry men and machines up to battlement level. Lines of sheds protected the workers. (Author's drawing)

usefulness of the siege tower and the battering ram. Nevertheless, a more pragmatic approach was adopted.

Sheds and shelters

From around 200 BC onwards, Roman besiegers often dealt with uneven terrain and sophisticated outer defences simply by burying them beneath a wide embankment (*agger*). In many cases, this necessitated piling up tonnes of earth and rubble, beginning some distance from the town and gradually moving closer; the larger embankments required timber shoring at the sides. At Avaricum in 52 BC, Caesar was obliged to build an *agger* 80ft (23.7m) high, as the town was situated on high ground amid impassable marshland. The embankment's width of 330ft (97.6m) amply accommodated the two siege towers that gave the men covering fire during the construction phase, but it was primarily designed to facilitate a mass infantry assault on the battlements.

Such large-scale earth-moving operations called for a different type of protection from the Hellenistic ditch-filling tortoises. Gangs of soldiers, passing brushwood and baskets of earth forward, required long covered passageways, and the men working at the front needed to be screened from the defenders on the town wall. The Romans often employed a shelter called the *vinea*, which Vegetius describes as a light timber structure, open-ended with wickerwork sides, a boarded roof, and a fireproof covering of rawhide. Arranged end-to-end to form long corridors, these are perhaps the devices which Caesar calls 'open tunnels' (*cuniculi aperti*).

Men emerging from these corridors required frontal protection, which was probably provided by the *pluteus*, a large convex wicker shield with an arched roof. Vegetius claims that its triangular base sat on three wheels, but such a basic device cannot have been heavy and must easily have been manhandled into position. Other shelters were no doubt improvised out of wicker and rawhide to suit the occasion.

The *vinea* and, to a lesser extent, the *pluteus*, were virtually ubiquitous in Roman siegecraft, owing to the fact that they were so useful in construction work. A third shelter, the *musculus*, appeared more rarely. Vegetius describes it as a small machine, reminiscent of the Hellenistic ditch-filling tortoise in its role of protecting men as they brought forward building materials. However, he is surely mistaken. From Caesar's description of the *musculus* in action during the siege of Massilia in 49 BC, it is clear that it was an enormously robust gallery, constructed when the standard *vineae* and *plutei* failed to stand up to the defenderers' formidable artillery. The extra protection was required by men moving

The siege ramp at Masada represents an extraordinary solution to a particular problem. It is likely that a gentler gradient was usually preferred. (Author's photo)

up to the enemy wall for undermining work. In other words, it was the Roman equivalent of the Hellenistic 'digging tortoise'.

Caesar's version was 60ft (18m) long, 4ft (1.2m) wide, and 5ft (1.5m) tall, with a pitched roof. It was built out of 2ft-thick (0.6m) timbers, and entirely covered with a fireproof layer of tiles and clay, followed by a waterproof layer of rawhide, to foil any attempts at dissolving the clay. It was perhaps unusual to mobilise such a structure; at any rate, the defenders were taken by surprise when it was suddenly advanced to the wall on sets of rollers normally used to transport ships. With the *musculus* in place at the wall foot, the defenders were powerless to prevent the Romans from undermining one of the city's towers.

Another specialised type of shelter is mentioned in a work entitled *Siegecraft* (*Poliorkētika*), addressed to an unnamed Roman emperor by the architect-engineer, Apollodorus of Damascus. In a section on combating objects rolled downhill by defenders who command the high ground, he likens the shelter to the prow of a ship (*embolon*). This concern with hilltop fortifications adds weight to the general suspicion that Apollodorus was writing at the time of the emperor Trajan's Second Dacian War (AD 105/6), which appears to have ended with the storming of native strongholds. Certainly, he was responsible for building the famous Danube bridge for this campaign, and he writes in the *Poliorkētika* of having previously served at the emperor's side, perhaps during the First Dacian War (AD 101/2).

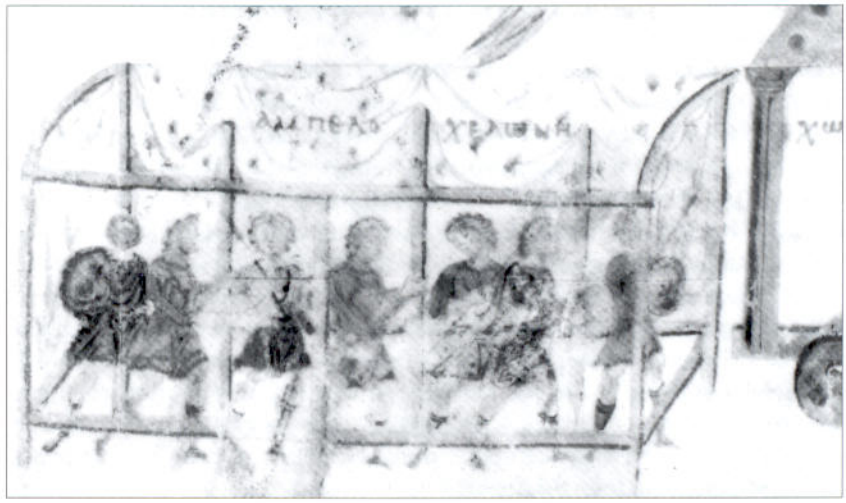
Defenders often rolled down tree trunks, heavily laden wagons and weighted barrels, to disrupt the ranks of the besiegers. Apollodorus suggests intercepting these and channelling them away by means of oblique ditches and reinforced palisades. Furthermore, he recommends that assault troops should crowd inside 'the tortoise shaped like the prow of a ship' for protection. Its triangular shape, with heavily reinforced apex facing uphill, was designed to deflect rolling objects. Apparently roofless, it was light enough for the soldiers to slide along like a sledge, and was wedged in position by a stout prop. By good fortune, this scenario is illustrated on Trajan's Column, in a scene that has been consistently misunderstood, owing to the juxtaposition of the shelters with the defenders' tree trunks and barrels.

The Roman siege tower

Again, from around 200 BC, Roman armies made increasing use of siege towers. On one of the earliest occasions, however, at the Greek town of Atrax, their inexperience with heavy machinery led to disaster, when a siege tower foundered on a poorly compacted embankment; one wheel became stuck in a rut, causing the machine to list violently, and the whole enterprise was abandoned. Later operations were conducted more successfully.

Vegetius gives a brief but comprehensive description of the mobile tower, as it might have appeared in the mid-1st century AD. He begins by emphasising that, for stability, different heights of siege tower required different base dimensions, and suggests bases of 30ft (8.9m), 40ft (11.8m), and 50ft (14.8m) square. Unfortunately, he does not mention the corresponding heights, but they would not have been excessive. Although ten-storey siege towers are recorded from the time of Caesar, the towers constructed during Rome's Jewish War varied from the 50ft (14.8m) examples at Jotapata in AD 67 to the 50-cubit (22.2m) ones at Jerusalem in AD 70. In each case, their height was commensurate with their role in providing suppressing fire to protect the men working on the embankment. It is true that the Romans used a 60-cubit (26.6m) machine to assault Masada in AD 73, but this was necessitated by the local topography. By and large, it is clear that, by the mid-1st century AD, the guiding principle of military engineering was functionality, in place of the Hellenistic fascination with awesome size.

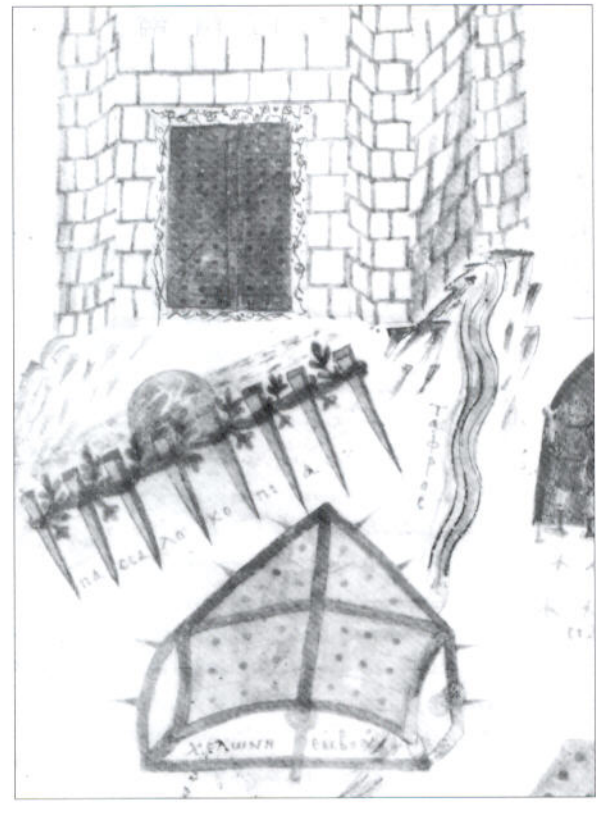
Vegetius mentions three distinct levels in his tower, but intermediate stages would have been inserted according to the desired height. At ground level, in an unusual departure from the Hellenistic design but entirely in keeping with Roman pragmatism, it was equipped with a battering ram. In the middle, it carried a boarding-bridge (*exostra*), 'made from two beams and fenced with wickerwork'. And at the top, it incorporated a fighting platform for spearmen and archers, whose task was to provide covering fire. Unfortunately, the undercarriage is not described, but Vegetius's reference to 'many wheels' suggests that there were more than the basic four, though we can only guess at their size and disposition.



Roman *vinea*. This 11th-century manuscript illustration shows Apollodorus's version of the shelter, which he compares to a vineyard trellis, because of the upright posts. (Vat. Gr. 1605 fol. 8; © Biblioteca Apostolica Vaticana/Vatican)

As a defence against fire, the entire structure was clad in rawhide and layers of rags; the rags would surely have been inflammable, unless they were stuffed beneath the rawhide to form a cushioned layer. Vegetius advises those opposing a siege tower to strip off the rawhide, whereupon the machine would be vulnerable to burning; if this cannot be accomplished, he says, the defenders must ensure that their incendiary missiles pierce the fireproof layer. It was probably to counter this risk that, during Rome's Jewish War (AD 66–73), the siege towers were clad with iron plates; the weight penalty must have been offset by the benefit of increased protection. Engineers may not always have been mindful of the extra stress that heavy cladding imposed on the framework, judging by the spontaneous collapse of one of the siege towers at Jerusalem in AD 70.

As far as the boarding-bridge is concerned, Vegetius calls it a 'bridge (*pons*) ... which the soldiers fix between the siege tower and the wall, when it is suddenly extended; using it to come out of the machine, they cross over into the town and occupy the walls.' It was evidently pushed forwards, but no construction details exist. Wickerwork fencing no doubt extended along each side, as much to prevent the soldiers from falling off as to give them a modicum of protection. It would have been important for such a bridge to be at the precise height of the enemy battlements, so that the soldiers would not have to negotiate an unfavourable gradient.



Renaissance manuscript illustration of Apollodorus's ship's-prow tortoise, showing the associated ditch and palisade running off at an angle to deflect any rolling objects. (Vat. Gr. 1605 fol. 8; © Biblioteca Apostolica Vaticana/Vatican)

Vegetius also mentions the *sambuca* as an alternative form of boarding-bridge. This device, he says, is so named from its similarity to a harp, for 'just as there are strings on a harp, so on a beam which is attached to the siege tower, there are ropes which lower a bridge from above by means of pulleys, so that it descends to the wall, and immediately the soldiers come out of the tower and, using it to cross over, they invade the town walls'. This is similar to the shipboard *sambuca* that differed substantially from Damios's wheeled version.

Finally, Vegetius briefly describes the unusual stratagem of incorporating within the tower a concealed turret, which could suddenly be hoisted into position using ropes and pulleys, if the defenders managed to heighten their walls. If this is anything more than a flight of fancy, the turret must have been of rather less substantial construction than the parent tower in order to be easily winched into place.

The siege tower of Apollodorus

The siege tower described by Trajan's engineer Apollodorus demonstrates a more basic design, perhaps tailored to particular circumstances where wood was in short supply. His instructions proceed point by point, and were apparently delivered to the emperor by a trained apprentice who was familiar with his master's machines.

Scene of a siege from Trajan's Column (Rome). The defenders roll barrels and tree trunks downhill (top right), but three peculiar machines intercept them. Lendle made the astute observation that these are likely to represent Apollodorus's ship's-prow tortoises. (Author's collection)

Apollodorus begins by recommending that, for safety, the erection of the siege tower be carried out at some distance from the enemy walls. This really goes without saying; it was, after all, the principal reason for furnishing the various machines with wheels, and as such will have been common practice. On the other hand, it was definitely not common practice for a military engineer to restrict himself to short beam-lengths, but Apollodorus's chief concern is the ready supply of materials; he proudly announces that, by following his instructions, 'using few and short timbers, a large tower is raised, equal in height to the wall'.

Indeed, the longest timbers were only 16ft (4.7m) long and 1¼ft (37cm) wide by 1 span (22cm) thick. The four corner uprights of the tower were triple thickness, and converged gradually towards the top. The base consisted of two pairs of parallel joists, with the wheels fixed between each pair. Unfortunately, Apollodorus does not elaborate on this, but there would have been ample space for two wheels per side, around 2½ft (74cm) in diameter, each on its own short axle.

Once it was built, the entire structure was boarded over with planks. Apollodorus first suggests that raw hides should be loosely hung all around to intercept missiles; he then recommends that the planks be fastened with broad-headed nails and covered with a thick layer of clay, a method of fire-proofing found on other machines. Later, almost as an afterthought, he recommends a primitive firehose device called the *siphōn*, consisting of ox intestines attached to leather sacks of water; theoretically, in the event of fire, squeezing the sacks would cause water to spray out.

The top storey remained open to the elements, but was provided with a parapet of boarding. The tower's purpose, as a protected staircase, was achieved by an internal system of ladders leading to a top-storey drawbridge of ingenious design. Hinged at the floor, its side-beams were 20ft (5.9m) long, but the drawbridge itself was solid for only a quarter of that; the remainder was an open frame, like a window. The result was that, while in the upright position, it appeared to be a continuation of the top storey parapet, forming as Apollodorus says 'a defence (*proteichisma*) for the fighters in the tower'. The drawbridge was operated by ropes

Scene of a siege from the Arch of Septimius Severus (Rome). A siege tower with projecting battering ram can be seen at bottom left. (Fototeca Unione, c/o American Academy in Rome)

running from the corner uprights, similar to Vegetius's *sambuca*. When these were released, the drawbridge lowered and a system of rush matting, strengthened with rigid crosspieces, was extended across the unboarded section, to create a solid bridge.

Apollodorus's tower probably required only three or four storeys to ensure that the drawbridge lay at wall-height. With its small footprint and compact design, it is quite a different machine from its Macedonian forebears. Apollodorus is perhaps mindful of the machine's stability when he recommends a specially levelled running surface: 'if the ground underneath is not smooth but has hollows, we shall construct a base (*hypothēma*) for the tower, with a similar arrangement [of beams?] as the tower, which evens out the slope of the ground and makes a level surface, on account of its construction'. This tantalisingly brief sentence may represent Apollodorus's description of the *agger*, or embankment, which became almost the hallmark of Roman siegecraft.

The Roman ram-tortoise

The battering ram remained the standard assault weapon throughout the period. The geographer Pausanias, writing around AD 150, provides the interesting information that walls of mud-brick withstood battering more effectively than stone walls, whose individual blocks tended to shatter or become dislodged. The same effect is noted by Apollodorus, who explains that brick walls absorb impact, whereas battering shakes stone walls apart. Nevertheless, by Roman times, the most common defences were of stone-faced rubble; demolishing the facing would cause the core to collapse.

Naturally, Apollodorus includes a ram-tortoise in his arsenal of machines. However, its four key design principles stand in stark contrast

On several occasions, the Germanic tribes attempted to build siege machinery, with limited success. This scene from the Column of Marcus Aurelius (Rome) depicts the 'Lightning Miracle', when the emperor is supposed to have called down a lightning bolt to destroy an enemy machine, here seen threatening a Roman fort. (Courtesy of Deutsches Archäologisches Institut, Rome)

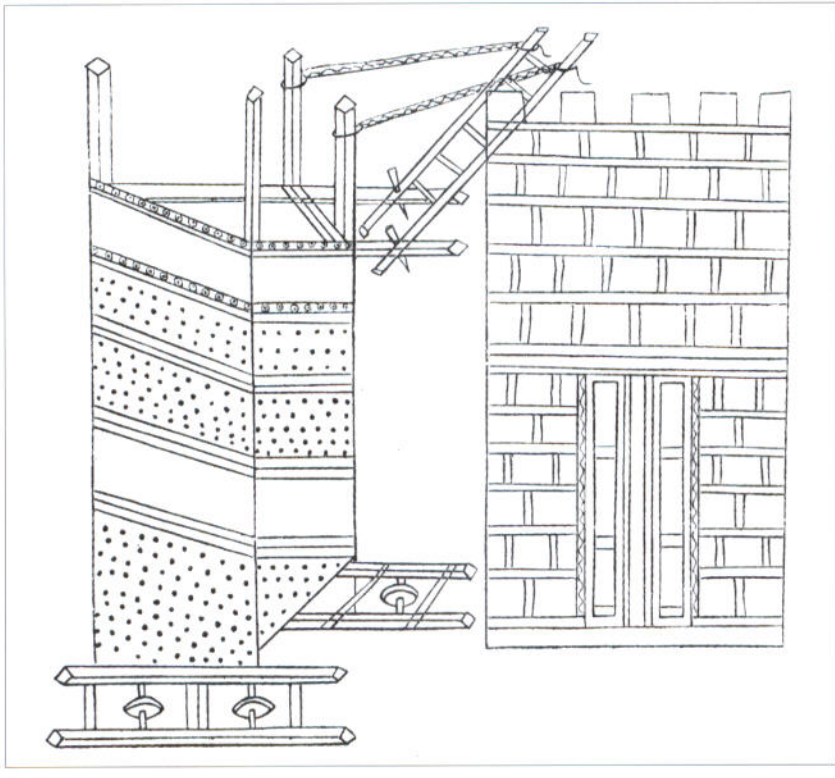
to the philosophy of Diades or Hegetor. First, the suspension ropes had to be long to allow the ramming-beam a full range of movement and produce a powerful battering action; second, the tortoise had to be compact and easy to move; third, the sides had to slope steeply so that heavy missiles would glance off without doing damage; and fourth, the ram head had to be protected from above by a projecting roof.

The design of the tortoise was certainly simple enough. Its 12ft-wide (3.5m) undercarriage comprised two pairs of joists, with the wheels located between each pair, just like the siege tower. Along each of the outer joists were four rafters, which rose at a steep angle to support a longitudinal ridge beam. The rafters were braced half way up by internal uprights, sitting on the inner joists, and the whole structure was strengthened by being boarded over with 1/4ft-thick (7cm) planks. During the ramming, Apollodorus recommends that the undercarriage be raised on wedges, to prevent the machine from rolling back with each blow.

The projecting roof was achieved by making the ridge beam longer than the undercarriage beams. Accepting a length of 24ft (7m) for the undercarriage, as proposed by the anonymous Byzantine, the ridge beam would then measure perhaps 30ft (9m) or so. This would certainly square with Apollodorus's stated aim of using short timbers to design easily transported machines.

Apollodorus suggests that the ramming-beam was hung so that the front end was longer, with a lead weight attached to the rear end to restore the balance; the result, he claims, was increased power, as if from a heavier beam. Rope binding is mentioned, but only in the context of constructing a composite beam from two or three shorter pieces. And, in contrast to the likes of Hegetor's ram, the head was slotted into the beam, and fastened by an iron collar to prevent the wood from splitting.

It seems to have been conventional to cast the iron ram head as an effigy of the actual animal's head. Proof of this comes from a brief description of the battering rams used during Rome's Jewish War (AD 66–73). Writing a generation earlier than Apollodorus, the historian



Apollodorus's siege tower. The practice of combining more than one viewpoint in a single diagram is evident in this 11th/12th-century manuscript illustration, where the two pairs of undercarriage joists are shown in plan view. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)

Josephus says, 'an immense beam, resembling the mast of a ship, is capped at the front by a mass of iron, modelled like a ram's head, from which it takes its name'. The later historian, Ammianus Marcellinus, who likewise had first-hand experience of the Roman army at war, this time in the eastern theatre of the AD 360s, gives a very similar description: 'A tall fir or mountain ash is selected, to the end of which is fixed a long, hard iron, manufactured in prominent likeness of a ram, a shape which gives its name to this machine.'

Although both historians witnessed the machine in action, they had little grasp of its structure, and may never have seen beneath the outer shed. Josephus vaguely states that 'it is hung by ropes in the middle, just like one of the beams of a balance, [and is] propped up by firmly-based uprights on each side'; elsewhere, he alludes to wickerwork panels and rawhides protecting the machine and its crew. Ammianus's version is similarly unclear: 'And so, suspended from transverse iron-bound beams, on both sides, as if from a pair of scales, it is held fast by ropes from another beam.' Josephus's frequent references to the machine as a *helepolis* should not mislead us into imagining something along the lines of Vegetius's combined tower and ram, for there is not the slightest hint that this is anything other than a ram-tortoise. Similarly, Ammianus's *helepolis*, which follows on from his discussion of the battering ram, is clearly a confused description of a ram-tortoise, but both historians' accounts are far too muddled to form the basis of a reconstruction.

By good fortune, two ram-tortoises can be seen on one of the sculptured panels of the Arch of Septimius Severus, which was erected in AD 203. Both depict the sloping roof and triangular cross section, characteristic of the Roman version of the machine, and Apollodorus's

recommendation that a second tortoise should follow behind, to shelter the ramming crew, is illustrated by one of the machines.

CONCLUSION

The same basic range of machines remained in use throughout the Roman period, although it is often claimed, on spurious grounds, that standards declined. In fact, the siege machinery observed on the eastern frontier in the AD 360s by Ammianus Marcellinus would have been recognised and appreciated by Julius Caesar four centuries earlier. Battering rams were still used to shake walls; siege towers were still used to elevate missile troops.

However, a major divergence with earlier Hellenistic siegecraft came with the Roman use of the embankment, or *agger*. This placed a different emphasis on siege machinery, and there was no longer a need for the gigantic towers of the Macedonians. At the same time, it is apparent that a more functional range of sheds and shelters was adopted, not least to accommodate the battering rams; the more fanciful devices, such as the *sambuca*, were used only infrequently.

Nevertheless, although the Hellenistic engineers had favoured gigantic size to overawe their opponents, the same basic arsenal of machines was employed throughout antiquity to try to neutralise or circumvent enemy fortifications.

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COLOUR PLATE COMMENTARY

A: THE DITCH-FILLING TORTOISE

According to Athenaeus, the ditch-filling tortoise could be rolled sideways as well as backwards and forwards, probably by briefly raising each corner in turn, and changing the orientation of the axle. Without experimentation, it is unclear how this was accomplished, but the large frame would have allowed a dozen or more men to congregate around each wheel assembly and jointly take its weight. With the machine in position, there would have been ample space in the interior for men to work unhindered, evening out depressions in the ground. The gap between the rafters and the ground would have been sufficient to allow baskets of earth and rubble to be brought in at the rear, from where they could be dragged forward for the task of ditch-filling.

The scene is based on the siege of Halicarnassus in 334 BC, when Alexander was obliged to fill the newly cut 13.5m wide, 7m deep defensive ditch, in order to bring up heavy machinery. The remains of the fortifications suggest that the curtain was a single-line, single-storey affair, but not enough survives for an accurate picture. Here, the reconstruction is based on the defences of Paestum (Italy), generally thought to have been built around 330 BC. The approximately 9m high wall is crowned by a closed battlement with shuttered windows, as a defence against escalade.

B: THE *SAMBUCA*

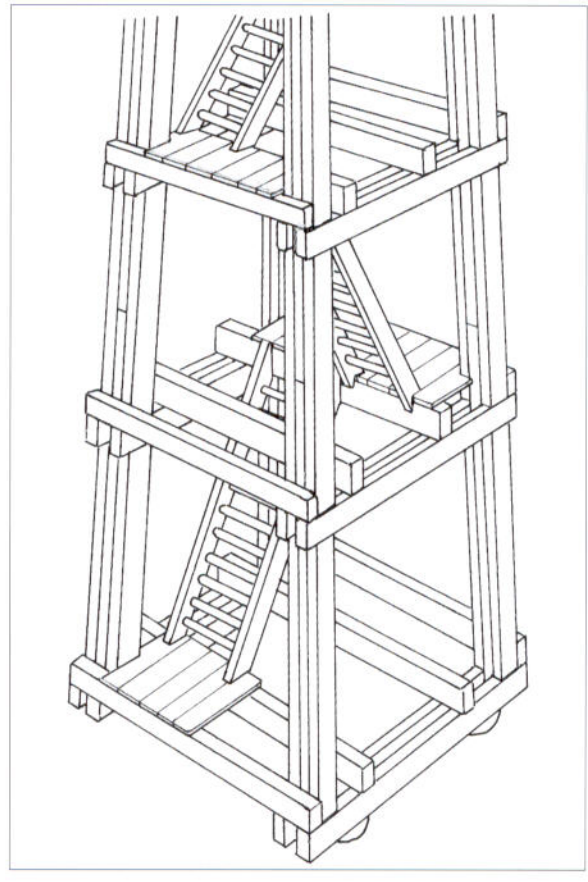
Biton's description of Damios's *sambuca* is extremely concise. For the undercarriage, he simply gives beam dimensions of 3ft x 2ft x 27ft (0.9m x 0.6m x 8 m) and notes that the wheels were 3ft (0.9m) high; here, a rectangular undercarriage with six wheels is assumed. The main component, a 60ft (18m) ladder, was hinged to the rear of the trestle, which supported a centrally located vertical screw; the screw's function was to raise and lower the main ladder. It is reasonable to suppose that as much of the machine as possible was boarded in, in order to protect the crew. Biton specifies that the trestle was 14ft (4.2m) high, whereas the screw was 15ft (4.5m) long; consequently, when fully turned, it would project 1ft (0.3m) above the trestle. Assuming a forward projection of around 12m for the ladder, with the screw fully turned, the assault platform rose almost 9m above ground level.

Maintaining the machine's stability would have been a delicate task. With the main ladder in its horizontal position, the vertical ladder at the front was perhaps to support the machine while the assault team took up position on the forward platform. Their presence there would have severely unbalanced the machine, so the counterweight at the rear must have been intended to restore its equilibrium. Only then would the main ladder have been elevated and the machine rolled forward.

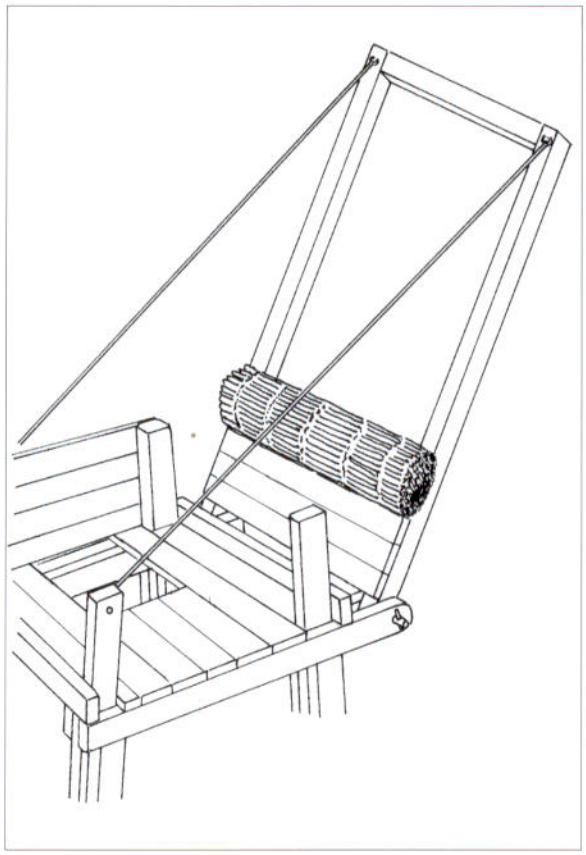
C: THE *HELEPOLIS* OF EPIMACHUS

With descriptions by four different ancient authors, this is the best known of all siege machines, but some uncertainties remain. Diodorus claims that the machine could move sideways, but does not explain the device that made this possible. The method of propulsion remains conjectural. According to Diodorus, 3,400 of the strongest men were employed, but there can only have been room for, at most, 800 of them to push against the joists of the undercarriage at any one time. This seems inadequate to move such an immense machine, and the assistance of draught animals has been postulated, in conjunction with pulleys anchored in the ground beneath the front of the *helepolis*. Of course, without experimentation, it is difficult to assess the practicalities of moving such heavy machinery.

This *helepolis* was used during Demetrius's siege of Rhodes in 304 BC. Although nothing has survived of the contemporary town defences, which were subsequently rebuilt on several occasions, they seem to have been relatively unsophisticated. The historical source, Diodorus, mentions neither outworks nor ditches, and the defensive artillery consisted mainly of arrow-firers. It is reasonable, then, to envisage the same kind of fortifications as are found at 4th-



Apollodorus's siege tower was built up from short timbers. The base is 16ft (4.7m) square. The 9ft (2.7m) uprights that support the first storey are doubled, with 16ft timbers sandwiched in between for added strength. (Author's drawing, following Lendle's interpretation)



Drawbridge on Apollodorus's siege tower. The near-side and rear boarding has been omitted for clarity. (Author's drawing, following Lendle's interpretation)

century Messene, with 9m high battlements and two-storey towers spaced at 100m intervals. By contrast, the sheer scale of the *helepolis* is staggering.

D: THE RAM-TORTOISE OF HEGETOR

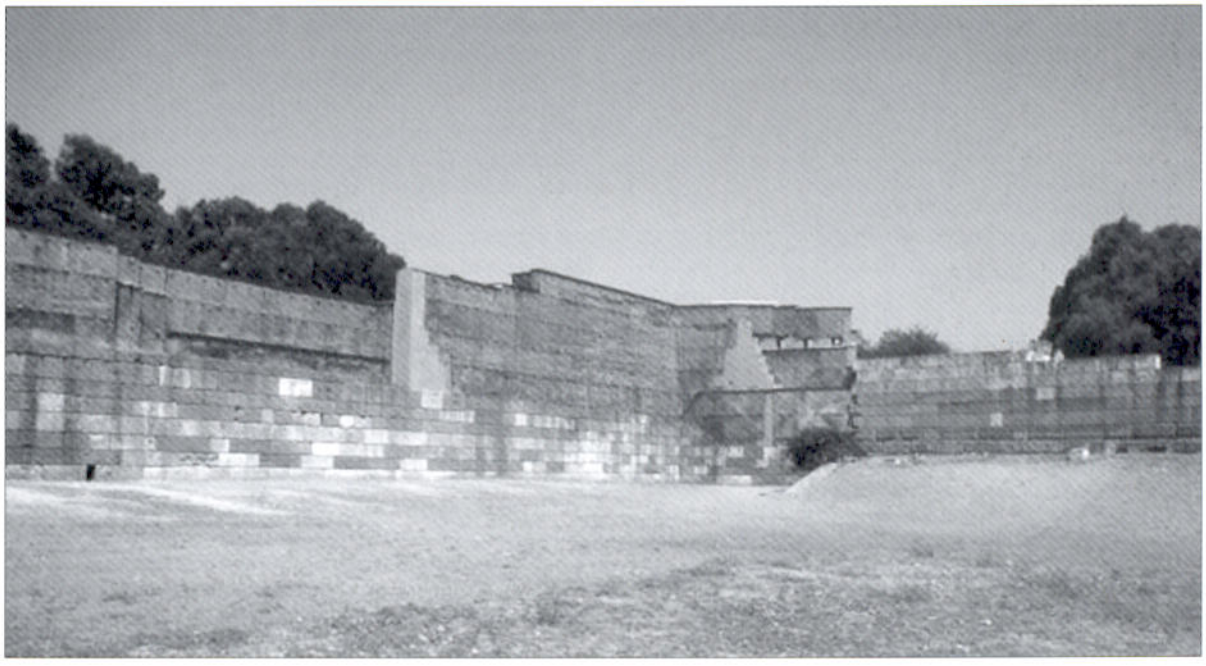
This machine is the subject of by far the most detailed of Athenaeus's and Vitruvius's descriptions, but doubts and misunderstandings have inspired a succession of astonishingly varied reconstructions through the years, and several uncertainties remain. In essence, Hegetor's machine was a 10m-high tortoise with a central turret, but the reconstruction of this key element is controversial. The sources give a detailed description of the ramming-beam itself, with rope reinforcement and rawhide covering. The beam was suspended from a rope cradle high up in the turret, and stabilised by rawhide-covered chains, running around a pair of rollers. Unfortunately, the sources omit to explain how the battering ram actually worked, but they appear to suggest that it could be elevated and lowered.

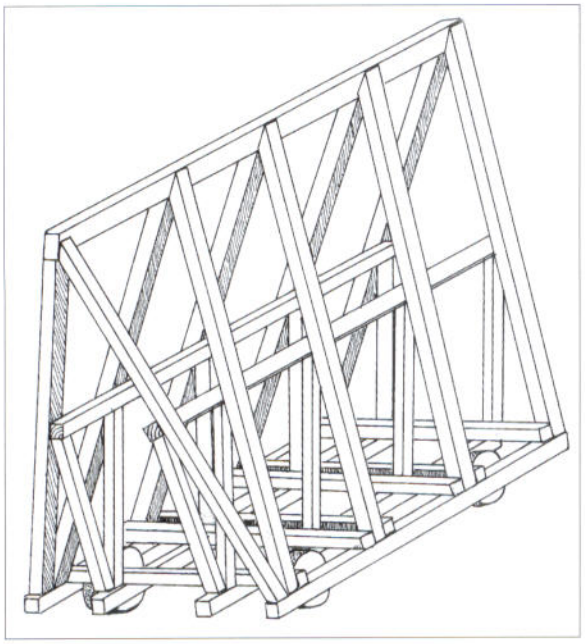
The use of the space above the internal compartment as a 'middle floor' can be seen, and the deployment of light artillery there implies shuttered windows in the front of the tortoise. Positioned roughly 9m above ground level, the catapults would have enjoyed a superior vantage point for targeting the average battlements.

E: ROMAN SHIP'S-PROW TORTOISE, WITH ASSOCIATED EARTHWORKS

Apollodorus opens his *Poliorkētika* with a scene of an assault

Mud-brick walls on top of masonry plinth at Gela (Sicily). The unusual height of the plinth has led to the suggestion that an original stone wall was heightened by adding brickwork. (Nigel Pollard. Image courtesy of *The Perseus Digital Library*, http:// www.perseus.tufts.edu)





Apollodorus's ram-tortoise, showing the internal arrangement of beams. (Author's drawing, following Lendle's interpretation)

on a hill town, in which he emphasises that the besiegers must guard against heavy objects being rolled downhill. He lists, in particular, tree trunks, round boulders, heavily laden wagons, and barrels filled with gravel or earth. First, he recommends the digging of 5ft (1.5m) deep ditches, running obliquely downhill; the spoil from the ditches forms a rampart, to break the momentum of the objects, and the ditches are intended to channel them away from the main besieging force, waiting further downhill. Next, he explains that the men digging the ditches should be protected by a slanting palisade line, boarded over and interwoven with branches to form an 'outwork' (*proteichisma*).

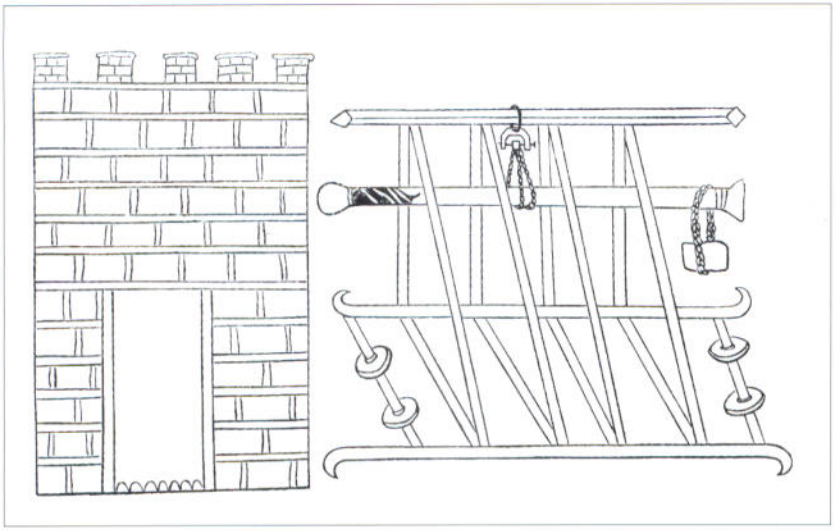
Finally, the key element in the scheme is the 'tortoise shaped like a ship's prow'. Apollodorus's brief description suggests a vertical-sided, open-topped shelter with triangular ground plan, arranged so that the apex, facing uphill, would deflect rolling objects to either side. Here, it is assumed that the vulnerable tip would have been reinforced with iron plating, and that the walls would have been sufficiently high to conceal the soldiers crowded inside.

The scene is based on the siege of a hilltop stronghold that appears on Trajan's Column and is perhaps intended to represent the Dacian capital, Sarmizegethusa. It has been assumed that the polygonal masonry of the *murus Dacicus* was surmounted by a timber breastwork, sections of which could easily be removed to allow heavy objects to be rolled down against Apollodorus's ship's-prow tortoises.

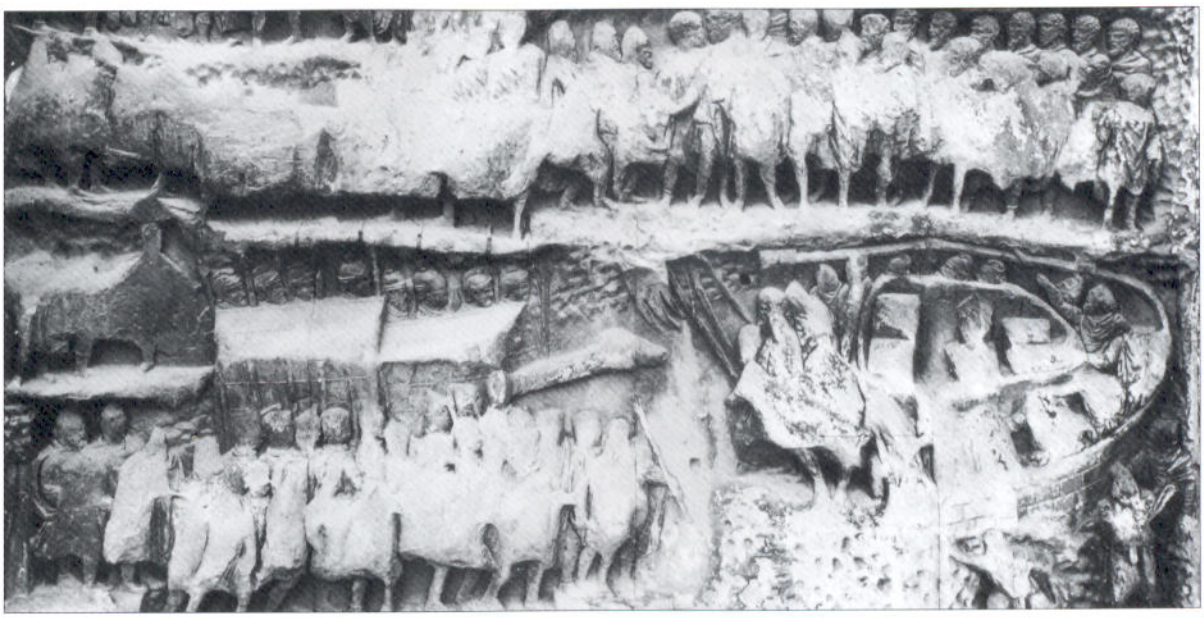
F: ROMAN SIEGE TOWER WITH DRAWBRIDGE

None of the historical accounts of Roman siege towers actually describes the machines, except occasionally to record the height. However, the late Roman writer Vegetius preserves a description of a tower that he perhaps borrowed from a lost work of the late-1st century AD. Within the tower, three distinct levels are specified: the lower level, housing a battering ram; the intermediate level, supporting a boarding-bridge; and the upper level, accommodating missile troops.

Of course, the number of individual storeys would have depended upon the desired height of the tower. Here, a siege tower roughly 50ft (c. 15m) tall is shown, necessitating four storeys. Vespasian employed iron-clad towers of this height during his siege of Jotapata in AD 67; individual iron plates were nailed onto the boarding. By contrast, Vegetius recommends a protective mattress of rawhide stuffed with rags. Of the two different types of boarding-bridge that he mentions, the *sambuca*-style drawbridge is shown; this, he says, was lowered by ropes and pulleys from a beam that was fixed to the rear of the tower. This is only one of a number of educated guesses that are necessary: similarly,



Apollodorus's ram-tortoise. Although basically correct, this 11th/12th-century manuscript illustration does not follow Apollodorus's instructions closely, presumably owing to the copyist's unfamiliarity with the machine. (C. Wescher, *Poliorcétique des Grecs,* Paris 1867)



ABOVE **Scene of a siege from the Arch of Septimius Severus (Rome). The ram-tortoise (centre) is followed by a second tortoise, for the protection of the ramming crew. (Fototeca Unione, c/o American Academy in Rome)**

the disposition of the wheels, design of the battering ram framework, and the method of climbing from one storey to the next are all uncertain.

G: ROMAN BATTERING RAM

Apollodorus's ram-tortoise is completely different from its Hellenistic precursors. A basically rectangular undercarriage, 3.5m wide, supports a ridge beam some 7m above the ground; this results in a steeply sloping roof, designed to deflect the projectiles that the enemy habitually dropped from the battlement. A major threat to battering operations was presented by millstones or stout timbers being thrown down onto the ramming-beam in order to snap off the head. To address this problem, Apollodorus extends the ridge beam forwards, carrying the roof of the tortoise over the ramming-beam, like a canopy, to protect it from above. Apollodorus specifies 4-daktyl (7cm) thick planking, covered with a similar thickness of clay mixed with hair; such a mixture stuck more readily to wickerwork, which often formed an intermediate layer over a siege machine's boarding.

The scene is based on Septimius Severus's second siege of Hatra (AD 199), a desert town in present-day Iraq. Severus allegedly breached the defences, so it is likely that his troops had raised an embankment against the outer wall, but the main enceinte seems never to have been in danger. In fact, the breach was repaired overnight, and a mutiny in his army forced Severus to withdraw. The historical sources preserve no details of Severus's siege machinery, but a contemporary sculpture depicts a ram-tortoise broadly similar to Apollodorus's model, with a second tortoise positioned behind, no doubt to protect the ramming crew.

BELOW **Ladders provided the simplest means of assault, but also the most dangerous, particularly if they fell short of the battlements. This Renaissance manuscript illustration depicts the lengthening of a ladder by means of a net, which is then hooked over the battlements. In an emergency, ladders could be made of rope or leather, and Aeneas Tacticus, writing around 350 BC, recommends that, after nightfall, defenders climb over the walls using nets, in order to recover spent ammunition. (C. Wescher, *Poliorcétique des Grecs*, Paris 1867)**

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The design, development, operation and history of the machinery of warfare through the ages.

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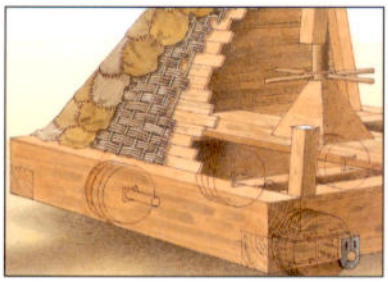

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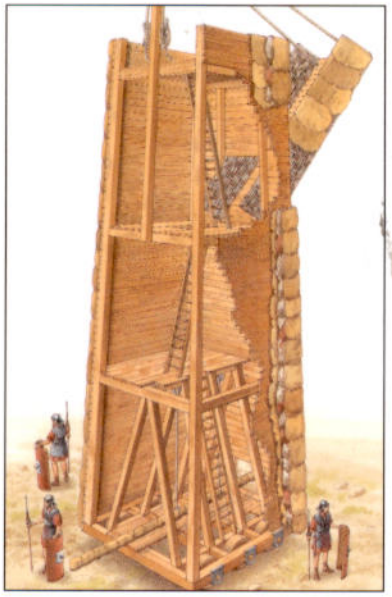
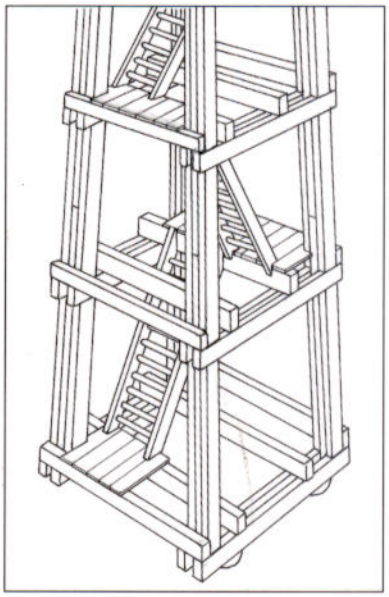


Cutaway artwork



Illustrations

Greek and Roman Siege Machinery 399 BC–AD 363

Siege machinery first appeared in the West during the Carthaginian invasion of Sicily in the late-5th century BC, in the form of siege towers and battering rams. After a 50-year hiatus these weapons of war reappeared in the Macedonian armies of Philip II and Alexander the Great, a period that saw the height of their development in the Ancient World. The experience of warfare with both the Carthaginians during the later-3rd century BC, and Philip V of Macedon during the early-2nd century BC, finally prompted the introduction of the siege tower and the battering ram to the Roman arsenal. This title traces the development and use of these weapons across this period.

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